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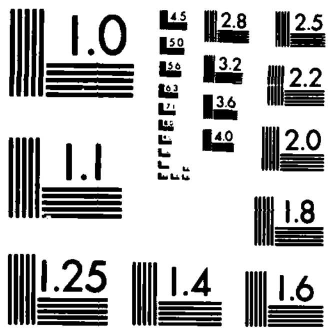

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Technical Report NAVTRAEQUIPCEN 80-C-0073-1

AUTOMATED INSTRUCTOR MODELS FOR LSO TRAINING SYSTEMS

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September 1982

TECHNICAL REPORT FOR PERIOD 23 JUNE 1980 - 23 JANUARY 1982

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the results of a project to define the functional elements required in an automated instructor model for Landing Signal Officer (LSO) training system. Documentation review and interviews with subject-matter experts provided information to support the definition of instructor model functions within the context of a fully automated training system for LSOs. This report, when combined with a companion volume entitled "Pilot Behavior Models for LSO Training Systems" becomes the functional definition of a

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Landing Signal Officer Training System (LSOTS).

The present report identifies instructor functions to be automated in a LSOTS, including instruction, performance assessment, performance feedback, maintaining trainee records, and individualized curriculum control. In addition, the report identifies the functional design characteristics of the training system executive, and the system interfaces with the trainee and the human instructor.

The characteristics of a software model intended to accomplish the instructor model functions are presented.

A LSO knowledge (data) base was generated to represent the important variables in the LSO's task during carrier aircraft recovery. A preliminary training syllabus was developed by sequencing the variables represented in the LSO knowledge base.

It was recommended that an LSOTS be developed and built based on the functional definitions and adhering to a procedure of repeated test, evaluate and revise (TEAR) cycles.

PREFACE

The authors express their appreciation to LCDR Jerry Singleton, LSO Training Model Manager and Officer in Charge of the LSO Phase I School. Mr. Singleton and his staff, Major Ted Lyons and LCDR Earle Rudolph, provided continued expertise and advice throughout the project. They should not be held responsible, however, for errors of fact or interpretation that may exist in the report. The authors believe that continued active participation of the LSO Training Model Manager will be required to facilitate the design and development of an effective automated LSO training system.

Mr. J. Thel Hooks was affiliated with Mathetics, Inc. of San Diego during his work on the project. His associate, Mr. Bill Clark, contributed to the software design of the instructor model.

Dr. Douglas C. Chatfield of Behavioral Evaluation and Training Systems, Inc. provided exceptionally helpful consultation on the development of instructor models.

We appreciate the tireless work of Rosemary Wescott in the preparation and production of the report.

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SECTION I

INTRODUCTION

BACKGROUND

A research and development program at NAVTRAEQUIPCEN has taken the initial steps toward developing an automated LSO training system. This work has been documented by Breaux (1980). As part of this program, a report by Hooks, Butler, Gullen, and Petersen (1978) presented a preliminary functional design for an aircraft-independent (multiple aircraft types) automated LSO training system. The design concept called for a stand-alone training system with a computer driven visual display of the approaching aircraft and related cues, automated speech recognition of LSO trainee voice calls, a pilot/aircraft model interacting in real-time with LSO calls, automated performance measurement, and syllabus control. This concept for an LSO training system (LSOTS) is being advanced in two studies for NAVTRAEQUIPCEN, the present report by Canyon Research Group, Inc. and another by Hooks and McMurry (in press).

Background information relevant to LSO training can be obtained from observation of the LSO Reverse Display (LSORD), an add-on capability to the A-7 Night Carrier Landing Trainer (NCLT). The LSORD provides a view of the NCLT simulated aircraft approach as seen from the LSO platform. While this LSO training device has some limitations, it appears to be a valuable tool for LSO training (Hooks and McCauley, 1980). It is aircraft dependent (A-7 only) and requires a pilot to fly the NCLT, except for a limited number of canned (recorded) approaches. Although some beneficial LSO training can be achieved with relatively inexperienced pilots flying the NCLT, a highly experienced pilot/LSO is required to optimize the training effectiveness of the LSORD. Such a pilot is capable of flying predefined approach profiles and demonstrating various pilot tendencies to support LSO training.

An instructor LSO must play a very active role to achieve training with the LSORD. He must set up the initial conditions for each approach, define the task, provide instruction, initiate the approach, assess the trainee's performance, provide performance feedback, and select the next task.

Two skilled people are required, therefore, to support LSO training in the LSORD - an instructor LSO and an experienced pilot. The lack of ready availability of such high-level personnel to support the LSORD almost certainly reduces its frequency of use. This is particularly true at NAS Lemoore, where fleet squadrons and a Fleet Replacement Squadron (FRS) are located. At NAS Cecil Field, the LSORD is used regularly by the LSO Phase I School as a part of the curriculum. For this application, two instructor LSOs are used to operate the LSORD. There is little doubt that an LSO training system which did not require full-time attendance of a pilot and an instructor would be more readily available and easier to schedule at any location. Furthermore, an LSOTS capable of simulating all fleet aircraft would serve the needs of the entire LSO community.

The LSOTS concept for LSO training seeks to reduce the instructor workload by automating many of the instructor functions as well as eliminating the need for a human pilot and providing the capability to simulate multiple aircraft-types.

INSTRUCTOR MODELS IN AUTOMATED TRAINING

Advances in automated voice technology have opened the door to new possibilities in the design of training systems (Breaux and Goldstein, 1975; Breaux and Grady, 1976). Many instructor functions can be automated, freeing the human instructor from mundane and repetitive tasks, and allowing him to function as a subject-matter expert, training supervisor, and instructional manager. Some of the instructor functions amenable to automation are trainee performance measurement, syllabus advancement control, task difficulty selection, and maintenance of trainee records. An automated instructor model can aid the human instructor by providing him with rapid access to summaries of trainee performance trends, and with information to manage the subsystems for problem presentation, performance measurement, and syllabus advancement.

The importance of these functions in an automated training system is clear. A recent study on instructor model characteristics emphasized their importance by stating: "In the instructor model, which is the control logic of the system, lies the success or failure of the automated training system itself" (Chatfield, Marshall, and Gidcumb, 1979, p.5). Further work on the characteristics of instructor models in voice-based training system has been reported recently by Chatfield, Klein, and Coons (1981). A robust instructor model is necessary for an effective automated LSO Training System.

STUDY OBJECTIVES

The major objectives of the present study were: 1) to identify the functions necessary in an automated LSO instructor model to provide information to the human instructor, maintain trainee records, and manage the subsystems for performance assessment, syllabus control, and task/problem generation; 2) to develop a model of the LSO instructor that incorporates these functions; 3) to develop a functional design for a software model that can utilize a pilot/aircraft model for generating instructional tasks (the pilot/aircraft model is reported in Hooks and McMurry, in press); and 4) to generate an LSO training requirement data base for use by the instructor model.

APPROACH

A top-down approach was used in identifying LSO instructor model functions. The major functions necessary to automate instructor aiding, performance assessment, and syllabus decisions were identified through review of LSO training literature, analysis of LSO training requirements, and interviews with the LSO Training Model Manager and his staff. Additional information has become available through the LSO survey data, collected by Hooks and McMurry (in press) in support of the development of the pilot/aircraft model.

Canyon views the present project as providing the link between the operational/training problem and the training system design specification. The product of this project is intended for use by a systems design team. The design team ideally will have both training/instructional specialists and systems design engineers. This design team concept is recommended so that the training system development can benefit from the combined expertise stemming from differing backgrounds. The design team can use the results of the present study and the pilot/aircraft model study as the functional definition of the LSO training system. This definition will require further elaboration of hardware, software and courseware to develop the LSOTS.

The guiding principles for design of the the training system are that it shall be student-centered, easy to use, and training effective. By "student centered" we mean that all interfaces and interactions with the student shall be based on human factors design principles. This applies not only to the traditional man-machine interfaces but to the organization, content and sequencing of the instructional interchanges with the student. Also, we suggest that user acceptance and training effectiveness will be enhanced by creative courseware development using humor and terminology appropriate to the LSO community.

Part of Canyon's approach to the LSO Instructor Model development was to continually be cognizant of the role of automated speech technology (AST) in the system. A special set of capabilities and limitations will be introduced by including AST (see Van Hemel, Van Hemel, King, and Breaux, 1980; and Cotton and McCauley, in press). AST will enable the system to have a stand-alone, instructorless capability, eliminating the need for a pilot and an instructor LSO to be present at all times during training. The AST allows the pilot/aircraft model to be responsive to LSO voice calls in real-time (eliminating the need for a human pilot) and it supports or replaces instructor tasks of performance assessment, performance feedback, syllabus advancement decisions, task difficulty selections, task generation, and record keeping. The important role of AST in the LSO training system is shown in Figure 1.

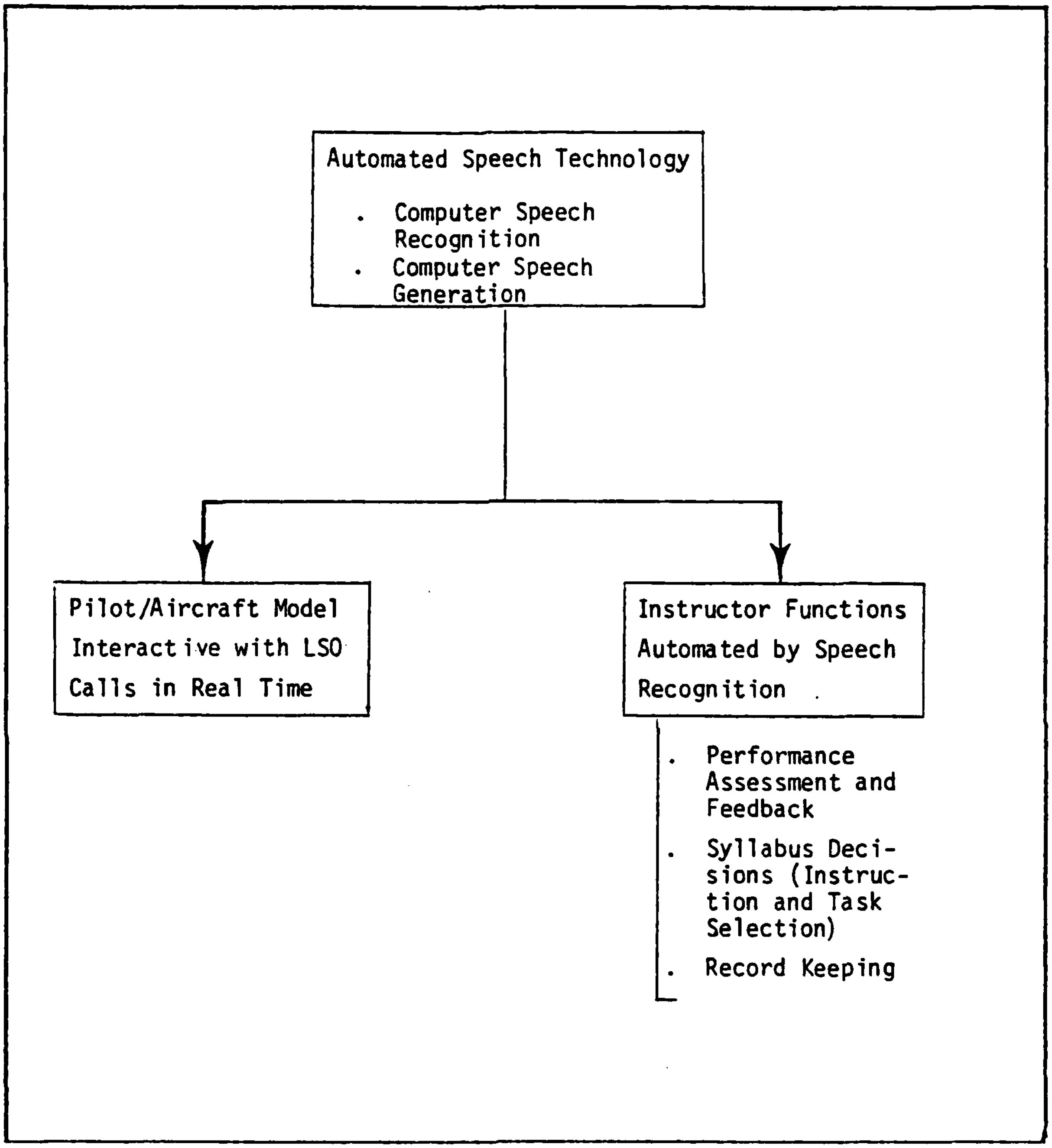

Figure 1. The Central Role of AST in an Automated LSO Training System.

While AST enables many instructor and pilot functions to be automated, it also introduces potential problems in system operation. These problems are largely based on current limitations of the technology, such as speech sampling requirements and recognition accuracy. The implications of recognition errors are important to consider in a highly connected system where the proper functioning of several subsystems is dependent on accurate speech recognition. Particular care must be given to design an "intelligent" system that minimizes the effect of occasional speech recognition errors.

SECTION II

INFORMATION SOURCES

The purpose of this section is to indicate the sources that were investigated, rather than to present a comprehensive literature review. Two procedures, manual and automated, were used to search and identify appropriate written sources. Interviews with the LSO Training Model Manager added substantial information.

AUTOMATED LITERATURE SEARCH

An automated literature search was conducted on-line at Canyon using the Lockheed Dialog system. The following data bases were searched: NTIS, COMPENDEX, PSYCHOLOGICAL ABSTRACTS, INSPEC, SCI SEARCH and COMPREHENSIVE DISSERTATION ABSTRACTS. The key search words were Landing Signal Officer, LSO, Carrier Landing, Carrier Aircraft Recovery, Adaptive Training, Adaptive Instruction, and Instructor Model. A complete listing of the sources identified was given in the Interim Report for this project.

MANUAL SEARCH

A manual search was conducted for publications and documents in the following categories: the LSO task; LSO modeling; LSO training; automated training systems; automated speech technology; instructor modeling.

The manual search was aided by the previous experience of two of the authors who have been involved previously in LSO studies.

The major documents and reports that were reviewed for the project are cited in the Bibliography.

LSO TRAINING MODEL MANAGER

The LSO Training Model Manager, and his staff at the LSO Phase I School at NAS Cecil Field, were an important source of information for the project. Information was obtained from them by direct interview, telephone exchanges, cassette tapes, and letters. The experience of the LSO Training Model Manager in the use of the LSO Reverse Display and other media for training LSOs was directly relevant to the functional design of the LSOTS. He and his staff provided not only subject-matter expertise, but insights into LSO training techniques. Finally, they provided useful critique and review of early versions of the developing Instructor Model.

SECTION III

INSTRUCTOR MODEL PRESENTATION

In accordance with NAVTRAEQUIPCEN format, the results of the LSO Instructor Model development are presented in Appendices A through C. Instructor model functions are described in Appendix A, Sections I - III, in context of the assumed structure and functions of the LSOTS.

Appendix B describes the design of a software model intended to accomplish the Instructor Model functions. This software model was designed to be compatible with the pilot/aircraft model reported by Hooks and McMurray (in press).

Appendix C presents a listing of the major concepts and variables in the LSO's task in carrier recoveries. This information represents a knowledge (data) base that can be used as a preliminary definition of LSO training requirements. A suggested training syllabus is presented in the second section of Appendix C by listing the contents of the LSO training requirements in a prescribed order.

Supplementary information and supporting materials are presented in Appendix D.

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

The LSOTS concept is worth pursuing because of its potential for effective training without the necessity for an instructor or pilot to be present.

The LSO Instructor Model (LSOIM) described in the appendices was designed to provide the following functions:

- o interact with a new LSO trainee to create appropriate records of previous experience and LSO qualification level
- o estimate the appropriate syllabus entry point for a new trainee
- o conduct familiarity exercises and demonstrations
- o generate voice data collection
- o brief the trainee (and instructor) on the objectives of a training session
- o provide appropriate instruction and tutorials
- o select appropriate task scenarios and practice problems
- o measure, assess and evaluate the trainee's performance
- o diagnose the trainee's strengths and weaknesses
- o individualize training by adjusting problem difficulty and syllabus pathway
- o provide remedial instruction/practice when necessary
- o maintain records of the trainee's performance
- o debrief the trainee at the end of a session
- o provide appropriate information to the human instructor on trainee progress

The design of the LSOIM is critical to the proper functioning of the LSOTS. The system to be built from this report must be trainee-centered (user-oriented), "intelligent," and flexible enough to accommodate changes in the curriculum. The LSOIM allocates considerable control of the training process to the trainee and the instructor by giving options and allowing overrides.

A data collection capability is recommended to track the selection of options and overrides by trainees and instructors. This capability can support subsequent revisions of the system.

The use of LSO terminology and humor in the courseware are advocated.

The development of certain "high risk" instructional technologies should occur in an independent experimental module. Examples are adaptive logic, and models for cognitive resource allocation and syllabus optimization. The operation of this module will be at the option of the instructor.

The system should be robust with respect to speech recognition errors. Development of "intelligent" software is recommended to produce acceptable pilot/aircraft responses based on all available task information, not solely on acoustic pattern matching of the LSO trainee's voice calls.

Extensive development of performance measurement and evaluation models will be required. The impact of errors in performance evaluation should be minimized by allowing the trainee the option to bypass performance feedback or to challenge it. The trainee must not be subjected to erroneous feedback or inappropriate remediation based on inaccurate performance measurement and evaluation.

The LSOTS should be subjected to an extensive in-plant test, evaluation and revision (TEAR) process (Cotton and McCauley, in press). This process should include thorough testing of the entire syllabus, using qualified LSO subject-matter experts. Appropriate courseware revisions and software debugging should be required before delivery.

The LSO Reverse Display can serve as a test bed for the concepts of the LSOTS.

The functional design information contained in this report and the companion volume (Hooks and McMurray, in press) defines the characteristics of the LSOTS. From this work and previous programs at NAVTRAEQUIPCEN, we conclude that the technology is sufficiently advanced to develop an effective system. The system, as defined, is a complex integration of advanced technologies that will require substantial time to build. We recommend that an LSOTS be developed and built as defined in order to enhance LSO training, and ultimately, the safety of carrier landing operations.

REFERENCES

Borden, G. J. The Landing Signal Officer: A Problem Analysis, Vol. I and II. Technical Report 785-1, Human Factors Research, Inc., Goleta, CA, 1969.

Baird, J.C. and Noma, E. Fundamentals of Scaling and Psychophysics. New York: John Wiley, 1978.

Breaux, R. Training Characteristics of the Automated Adaptive Ground Controlled Approach Controller Training System (GCA-CTS). Technical Note NAVTRAEQUIPCEN TN-52. Naval Training Equipment Center, Orlando, FL, 1976.

Breaux, R. (Ed.) LSO Training R&D Seminar NAVTRAEQUIPCEN IH-320. Naval Training Equipment Center, Orlando, FL, January, 1980.

Breaux, R. and Goldstein, I. Developments of Machine Speech Understanding for Automated Instructional Systems. In Eighth NTEC/Industry Conference Proceedings. Naval Training Equipment Center, Orlando, FL, November, 1975.

Breaux, R. and Grady, M.W. The Voice Data Collection Program: A Generalized Research Tool for Studies in Speech Recognition. In Ninth NTEC/Industry Conference Proceedings. Naval Training Equipment Center, Orlando, FL, November, 1976.

Brictson, C.A., Burger, W.J., and Wulfeck, J.W. Validation and Applicatin of a Carrier Landing Performance Score: The LPS . Inglewood, CA: Dunlap and Associates, Inc., March, 1973. (AD 910 514L)

Chatfield, D.C. and Gidcumb, C.F. Optimization Techniques for Automated Adaptive Training Systems. Technical Report NAVTRAEQUIPCEN 77-M-0575. Naval Training Equipment Center, Orlando, FL, 1977.

Chatfield, D.C., Marshall, P.H., and Gidcumb, C.F. Instructor Model Characteristics for Automated Speech Technology. Technical Report NAVTRAEQUIPCEN 79-C-9985. Naval Training Equipment Center, Orlando, FL, 1979.

Chatfield, D.C., Klein, G.L., and Coons, D. INSTRUCT: An Explanation of the Role of Artificial Intelligence in Voice-Based Training Systems. Technical Report NAVTRAEQUIPCEN 80-C-0061-1. Naval Training Equipment Center, Orlando, FL, 1981.

Chatfield, D.C. Personal Communication, January, 1981.

Cotton, J.C. and McCauley, M.E. Voice Technology Design Guides for Navy Training Systems. Technical Report NAVTRAEQUIPCEN 80-C-0057-1. Naval Training Equipment Center, Orlando, FL, in press.

Erickson, D.P. Landing Signal Officer Guide and Training Plan, circa 1978.

Greenstein, J.S. and Rouse, W.B. A Model of Human Event Detection in Multiple Process Monitoring Situations. Proceedings of the Fourteenth Annual Conference on Manual Control, University of Southern California. Moffett Field, CA: NASA, Conf. Publ. 2060, 1978.

Hooks, J.T., Butler, E.A., Gullen, R.A. and Peterson, R.J. Design Study for an Auto-Adaptive Landing Signal Officer Training System. Technical Report NAVTRAEQUIPCEN 77-C-0109-1. Naval Training Equipment Center, Orlando, FL, 1978.

Hooks, J.T., Butler, E.A., Reiss, M.J. and Petersen, R.J. Landing Signal Officer Laboratory System Software. Technical Report NAVTRAEQUIPCEN 78-C-0151-1. Naval Training Equipment Center, Orlando, FL (1980)

Hooks, J.T. and McCauley, M.E. Training Characteristics of LSO Reverse Display. Technical Report NAVTRAEQUIPCEN 79-C-0101-2. Naval Training Equipment Center, Orlando, FL, 1980.

Hooks, J.T. and McMurry, W.S. Pilot Behavior Models for LSO Training Systems. Technical Report NAVTRAEQUIPCEN 80-C-0063-1. Naval Training Equipment Center, Orlando, FL, in press.

Joplin, L. Interactive Logs for Automated Speech Technology. Technical Report NAVTRAEQUIPCEN 79-C-0066-1. Naval Training Equipment Center, Orlando, FL, May, 1980.

McCauley, M.E., Root, R.W., and Muckler, F.A. Training System Evaluation of PACTS AIC. Technical Report NAVTRAEQUIPCEN 81-C-0055. Naval Training Equipment Center, Orlando, FL, in preparation.

McCauley, M.E. and Borden, G.J. Computer Based Landing Signal Officer Carrier Aircraft Recovery Model. Technical Report NAVTRAEQUIPCEN 77-C-0110-1. Naval Training Equipment Center, Orlando, FL, 1980 (in press).

McCauley, M.E. and Semple, C.A. Precision Approach Radar Training System (PARTS) Training Effectiveness Evaluation. Technical Report NAVTRAEQUIPCEN 79-C-0042-1. Naval Training Equipment Center, Orlando, FL, August, 1980.

Mecherikoff, M. and Mackie, R.R. Attitudinal Factors in the Acceptance of Innovations in the Navy. ONR Technical Report 784-1. Goleta, CA: Human Factors Research, Inc., June, 1970.

Van Hemel, P.E., Van Hemel, S.B., King, W.J. and Breaux, R. Training Implications of Airborne Applications or Automated Speech Recognition Technology. Technical Report NAVTRAEQUIPCEN 80-D-0009-0155-1. Naval Training Equipment Center, Orlando, FL, October, 1980.

VAQ-129, Carrier Aircraft Recovery Simulator (CARS), Proposal Letter, NAS Whidbey Island, 26 May 1976.

BIBLIOGRAPHY

Atkinson, R.C. Adaptive Instructional Systems: Some Attempts to Optimize the Learning Process. In D. Klahr (Ed.) Cognition and Instruction, New Jersey: Erlbaum & Assoc., 1976.

Barber, G. and Hicklin, M. Precision Approach Radar Controller Training System Functional Specification. Technical Report NAVTRAEQUIPCEN 77-C-0162-7. Naval Training Equipment Center, Orlando, FL, February, 1980.

Borden, G.J., The Landing Signal Officer: Display Requirements for ACLS Recoveries. Human Factors Research, Inc., Goleta, CA, 1972.

Borden, G.J., The Landing Signal Officer: Work Station Design. Technical Report 1707. Human Factors Research, Inc., 1970.

Brictson, C.A., Evaluation of the Special senses for Flying Duties: Perceptual Abilities of Landing Signal Officers (LSOs). Dunlap and Associates, Inc., La Jolla, CA, 1974.

Brictson, C.A. LSO Performance Meausrement. In R. Breaux (Ed.) LSO Training R&D Seminar. NAVTRAEQUIPCEN IH-320. Naval Training Equipment Center, Orlando, FL, January, 1980.

Brictson, C.A., Breidenbach, S.T., Narsete, E.M., Pettigrew, K.M. Objective Measures of Landing Signal Officer (LSO) Performance During Night Carrier Recovery. Technical Report NAVTRAEQUIPCEN 78-C-0123-1. Naval Training Equipment Center, 1980.

Chatfield, D.C. Instructor Model Characteristics for the LSO: The Bridge Between 6.1 and 6.2. In R. Breaux (Ed.), LSO Training R&D Seminar. NAVTRAEQUIPCEN IH-320. Naval Training Equipment Center, Orlando, FL, January, 1980.

Clark, W., Halley, R., Regelson, E., Slemon, G., Ver Steeg, R., et al. Functional Design for Air Intercept Controller Prototype Training System. Technical Report NAVTRAEQUIPCEN 78-C-0182-8. Navy Training Equipment Center, Orlando, FL, November, 1979.

Dixon, N.R. and Martin, T.B. (Eds.) Automatic Speech and Speaker Recognition. New York: IEEE Press, 1979.

Durand, T.S. and Wasicko, R. J. Factors Influencing Glidepath Control in Carrier Landing. Journal of Aircraft, 1967, 4, 146-158.

Halley, R.J., Hooks, J.T., Lankford, H.G., and Howell, L.H., Behavioral Objectives for Air Intercept Controller Prototype Training System. Technical Report NAVTRAEQUIPCEN 78-C-0182-1. Naval Training Equipment Center, Orlando, FL, February, 1979.

Hicklin, M., Barber, G., Bollenbacher, J., Grady, M., Harry, D., Meyn, C., and Slemon, G. Ground Controlled Approach Controller Training System (GCA-CTS) Final Technical Report. Technical Report NAVTRAEQUIPCEN 77-C-0162-6. Naval Training Equipment Center, Orlando, FL, April, 1980.

Kahneman, D. Attention and Effort. Englewood Cliffs, New Jersey: Prentice-Hall, 1973.

Keele, S.W. Attention and Human Performance. Goodyear Publishing Company. Pacific Palisades, CA, 1973.

Kelley, C.R. What is Adaptive Training? Human Factors, 1969, 11(6), 547-556.

Klahr, D. (Ed.) Cognition and Instruction. Lawrence Erlbaum Associates. Hillsdale, NJ, 1976.

Lea, W.A. (Editor). Trends in Speech Recognition, Englewood Cliffs: Prentice-Hall, 1980.

LaBerge, D. Perceptual Learning and Attention. In W.K. Estes (Ed.) Handbook of Learning and Cognitive Processes, Vol. 4. Erlbaum and Associates, Hillsdale, New Jersey, January, 1976.

Lacy, J.W. and Meshier, C.W., Development of a Landing Signal Officer Trainer, Proceedings, First Interservice/Industry Training Equipment Conference. Technical Report NAVTRAEQUIPCEN IH-316, Naval Training Equipment Center, 1979, 79-90.

Mears, Mike, MOVLAS Techniques for Pilots and LSOs, Approach. Naval Safety Center, 1976.

Nave, R.L. A Pilot/LSO Simulation Conducted to Investigate Aircraft Waveoff Performance and to Determine the Ability of the Landing Signal Officer to Judge Aircraft Approaches. NADC-74112-30, Naval Air Development Center, Warminster, PA, 1974.

Navon, D. and Gopher, D. On the Economy of the Human Processing System. Psychological Review, 1979, 86, 214-255.

Netherland, R.M., The Total Approach, Approach, Naval Safety Center, 1965.

Posner, M.I. Chronometric Explorations of Mind. Erlbaum and Associates. Hillsdale, New Jersey, 1978.

Posner, M.I. and Boies, S.J. Components of Attention. Psychological Review, 1971, 78, 391-408.

Reigle, M.E. and Smith, R.H., Preliminary Study of Optimal Waveoff Control: A Parametric Approach. NADC-72079-VI. Naval Air Development Center, Warminster, PA, 1973.

Saunders, G.J., LSO - The Forgotten Man, Approach, Naval Safety Center, 1977.

Smith, R.H., LSO-Pilot Interviews on Carrier Approach, VT-TM-1681, Naval Air Development Center, Warminstor, PA, 1973.

Smith, R.H., The Landing Signal Officer: A Preliminary Dynamic Model for Analyses of System Dynamics. NADC-72078-VT. Naval Air Development Center, Warminister, PA, 1973.

Stueck, Phillip Gary, LSO Pilot Interaction Simulator. Naval Postgraduate School, Monterey, CA, June, 1973.

U.S. Navy, Officer of the Chief of Naval Operations. The Naval Air Training and Operating Procedures Standardization (NATOPS) Program Manual, CV, Department of the Navy, 1975.

U.S. Navy, Office of the Chief of Naval Operations, The Naval Air Training and Operating Procedures Standardization (NATOPS) Program Manual, Landing Signal Officer (LSO) NATOPS, Department of the Navy, 1975.

Webb, G.J., The In-Close Waveoff, Approach, Naval Safety Center, 1976.

Williges, B.H. and Williges, R.C. Learner-Centered vs Automatic Adaptive Motor Skill Learning. Journal of Motor Behavior, 1977, 9, 325-331.

Woolridge, L., Kelly, M.J., Vreuls, D., Cotton, J.C., Martin, E. and Norman, D.A. Adaptive Performance Testing System for Surplus Attack Tasks in the Advanced Simulator for Pilot Training. Technical Report AFHRL-TR-80. Westlake Village, CA: Canyon Research Group, Inc. 43-3062, AFHRL and NAVTRAEQUIPCEN, 1980.

Woolridge, A.L., Vreuls, D. and Norman, D.A. An Adaptive Logic Study: A Study of Various Adaptive Logic Efficiencies. Technial Report NAVTRAEQUIPCEN 76-C-0079-1. Naval Training Equipment Center, Orlando, FL, 1977.

ACRONYMS

ACLS	-	Automatic Carrier Landing System
AOA	-	Angle of Attack
APC	-	Automatic Power Compensation
AST	-	Automated Speech Technology
CATCC	-	Carrier Air Traffic Control Center
CC	-	Curriculum Control
CCA	-	Carrier Controlled Approach
CRT	-	Cathode Ray Tube
CUR	-	Curriculum (Data File)
CQ	-	Carrier Qualification
DLC	-	Direct Lift Control
EMCON	-	Emission Control
FCLP	-	Field Carrier Landing Practice
FLOLS	-	Fresnel Lens Optical Landing System
FRS	-	Fleet Replacement Squadron
GS	-	Glide Slope
HII	-	Human Instructor Interface
HLL	-	High Level Language
ISD	-	Instructional System Development
LSO	-	Landing Signal Officer
LSO HUD	-	LSO Head Up Display
LSOIM	-	Landing Signal Officer Instructor Model
LSORD	-	LSO Reverse Display
LSOTS	-	Landing Signal Officer Training System
LU	-	Line Up
MOVLAS	-	Manually Operated Visual Landing Aid System
NATOPS	-	Naval Air Training and Operating Procedures Standardization
NCLT	-	Night Carrier Landing Trainer
NAVTRAEQUIPCEN	-	Naval Training Equipment Center
PAM	-	Pilot/Aircraft Model
PC	-	Performance Criteria (Data File)
PLAT	-	Pilot Landing Aid Television
PME	-	Performance Measurement and Evaluation
REQ	-	Prerequisite Training Requirements
SDC	-	Simulation and Display Control
SDT	-	Signal Detection Theory
SG	-	Scenario Generator
SGS	-	Speech Generating Subsystem
SME	-	Subject-Matter Expert
SRD	-	Speech Reference Data (Data File)
SRS	-	Speech Recognition Subsystem
TDM	-	Training Development Module
TI	-	Trainee Interface
TKDB	-	Trainee Knowledge Data Base (Data File)
TR	-	Trainee Records (Data File)
TSE	-	Training System Executive
VAR	-	Instructional Variables
WO	-	Wave Off
WOD	-	Wind Over Deck

APPENDIX A

LSO INSTRUCTOR MODEL DESIGN

SECTION A-I - INSTRUCTOR MODEL DESIGN

A1.1 PURPOSE

The purpose of the LSOIM development is to describe the functional characteristics required of an automated instructor model to support LSO training in a fully automated LSO training system (LSOTS). The LSOIM must be combined with the pilot/aircraft model functions described in another report (Hooks and McMurry, 1981) to complete the functional description of the LSOTS. The pilot/aircraft model was intended to provide guidance in the implementation of simulation functions for representation of carrier landing situations in support of automated LSO training.

The present report is directed toward the automation of instructor functions in an LSOTS, including instruction, performance assessment, performance feedback, maintenance of trainee records, and individualized curriculum control. In addition, the LSOIM covers the functional design characteristics of the trainee/system interface, the human instructor/system interface, and the training system executive.

A1.2 LSO INSTRUCTOR MODEL PRESENTATION

The LSOIM presentation in this appendix is divided into three sections: First, an overview of the instructor model and its role in the LSOTS will be described in this section (A-I).

Second, the LSOIM Functional Design (Section A-II) describes the primary functions to be accomplished by the Instructor Model. It organizes the functions into system modes of operation. The functional characteristics of the LSOIM are then discussed with respect to each mode.

Third, the LSOIM System Design (Section A-III) describes the systems organization of the LSOTS, with emphasis on the Instructor Model. The relationship between major system elements is presented, along with the primary program modules of the software organization. The design features and characteristics of the major system elements are discussed, including development modules for eventual system optimization. The automated voice subsystem is described in some detail, because its proper operation is critical to the success of an automated LSOTS.

A1.3 INSTRUCTOR MODEL OVERVIEW AND LSOTS ASSUMPTIONS

The automated LSOTS is envisioned as a stand-alone system capable of training one LSO (and possibly two, i.e., a back-up LSO) without the need for a human pilot or instructor: Figure A-I-1 shows a possible layout of the major physical features of the LSOTS. An automated voice

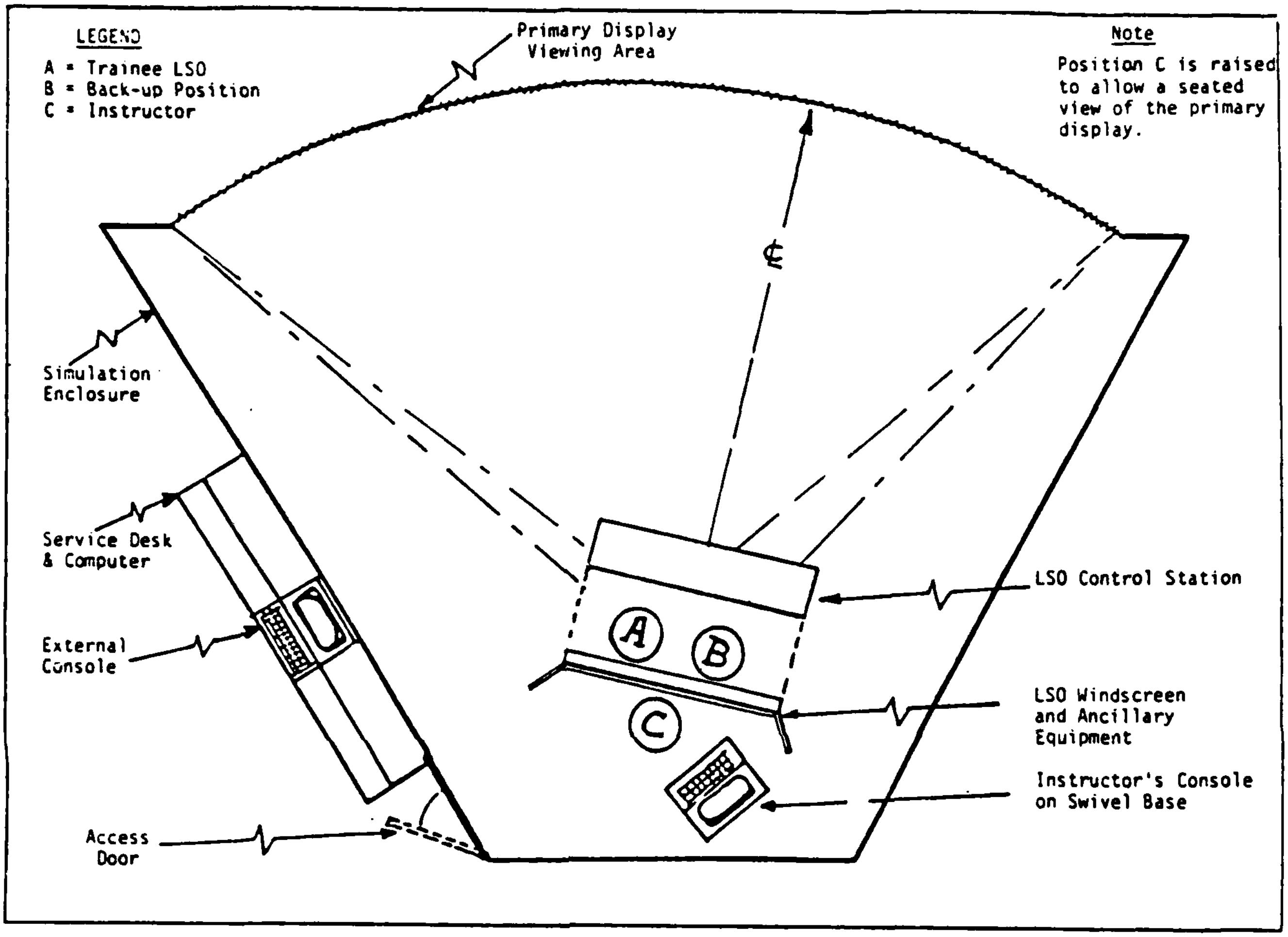

Figure A-I-1. General Arrangement of Landing Signal Officer Training System

system (both speech recognition and speech generation) will enable the trainee to: 1) interact with a simulated pilot/aircraft; and 2) to have his verbal performance assessed automatically, reducing the need for continual monitoring by a human instructor. A human instructor would oversee the training on an intermittent basis, and would have the capability to interact with the system to supervise, redirect, and supplement the automated training. The LSOTS is envisioned as having the capability to provide training to the entire range of LSO skill and qualification levels, from basic (Phase I) training through Wing LSO. It will be capable of simulating a wide range of environmental, operational, and situational variables that can affect the LSO's job in a carrier aircraft recovery.

The LSOTS is not envisioned as the only LSO training aid, but as one instructional component within the overall LSO training program. Other methods and media will be used within this program, including academics, field carrier landing practice (FCLP), and actual carrier landing operations.

The functional components or subsystems of the LSOTS are depicted in Figure A-I-2 and will be discussed in the following order to introduce their functions and interrelationships:

- Training Knowledge Data Base
- Trainee Model
- Curriculum Control
- Scenario Generator
- Pilot/Aircraft Model
- Voice System
- Performance Measurement and Evaluation
- Training System Executive

In addition, a training scenario example has been included to demonstrate the interaction of the various functional components listed above.

TRAINING KNOWLEDGE DATA BASE. The knowledge base (or data base) is a file of the subject-matter content. An initial definition of the data base for the LSOTS is given in Appendix C. Eventually, it must contain the complete enumeration of all task variables, their values, and appropriate performance measures.

The knowledge base entries must be completed through task analysis with the help of subject matter experts (SME), coordinated through the LSO Training Model Manager. The knowledge base provides the foundation for the content of the training program. It provides information for syllabus design, event simulation parameters, and performance measurement rules. It contains the raw data which are used by other subsystems of the LSOTS. The knowledge base will be organized into a taxonomy representing the smallest meaningful instructional units.

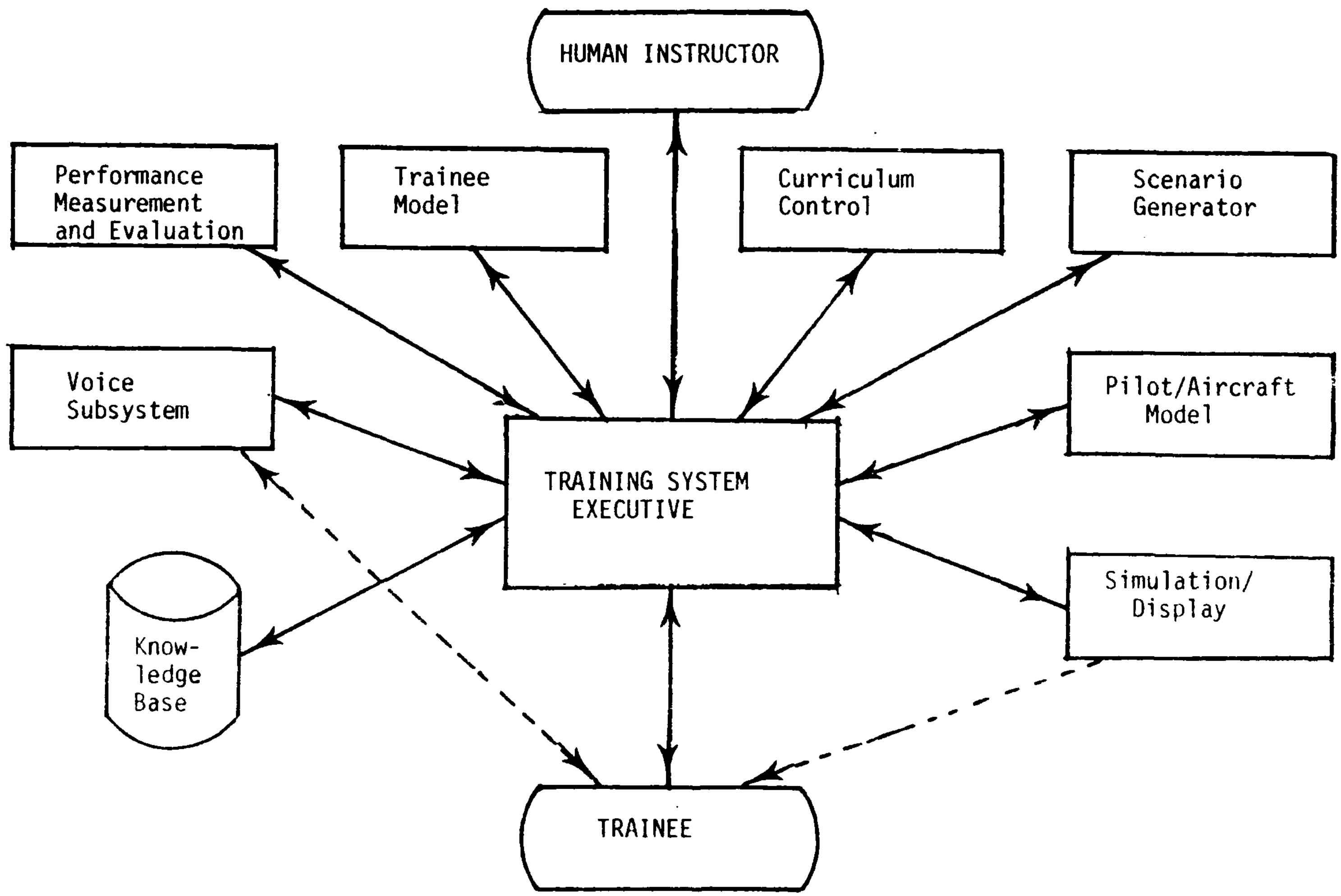

Figure A-I-2. A Candidate Top-Level Functional Description of the LSOTS

TRAINEE MODEL. The trainee model is a representation of the knowledge-state of the trainee at any time during training. It provides inferences about the trainee's status to enable (1) appropriate tasks (instructional units and scenarios) to be selected by the curriculum controller, (2) status reports to be generated for the instructor or trainee record files. The trainee model will receive input from the performance and evaluation module and will transform this input into a representation of his knowledge and skill in the LSO's task domain. This information also will be stored in a record of the trainee's progress in training.

Chatfield, Marshall and Gibcumb (1979) reviewed the function of a student model for automated training systems and discussed as several alternative techniques for developing student models. Chatfield, Klein and Coons (1981) have advanced the concept of instructor and trainee models for voice-based automated training systems.

The trainee model for the LSOTS is currently envisioned as a development tool that, when fully developed, will optimize the training sequence in terms of task selection for the individual trainee. The LSOTS adaptive logic and task generation will not be totally dependent, however, on the full development of the trainee model. The LSOTS will be capable of generating a reasonable syllabus pathway for each trainee without full reliance on a functioning trainee model. This modular approach will enable the LSOTS to train reasonably efficiently while the trainee model is undergoing development.

CURRICULUM CONTROL. The curriculum control module of the LSOTS provides the capability for automated adaptive syllabus logic, thereby reducing the work load of the instructor. The curriculum control takes information from the performance measurement and evaluation subsystem and the trainee model and makes decisions about what information, instruction or practice problems should be given to the trainee. The objective is to make the trainee work hard enough to maintain interest and optimal learning while not being so difficult that the trainee becomes overwhelmed or discouraged. The data base (knowledge base) design of the LSOTS will enable a large number of scenarios or tasks to be explicitly defined and stored. The current conception of the operation of the curriculum control is that a linear syllabus will be generated as a starting point, based on the information presented in Appendix C. The second level of development will be to establish an adaptive logic, whereby each student may progress through the course at his own pace. The mechanism for accomplishing the design of the adaptive logic has not been established at this time. The adaptive logic will control both the course sequence and the difficulty of each problem.

Chatfield et al. (1979) reviewed instructor model characteristics for automated training systems, including an in-depth analysis of alternative adaptive logic strategies. Chatfield and Gidcumb (1977) discussed optimization techniques for adaptive logics, whereby a system could self-organize through data collection on initial trainees exposed to the training system.

The final step in sophistication for the curriculum control is to include estimates of cognitive resource allocation. This procedure is intended to assist in determining when a trainee is prepared to advance in the syllabus or to be challenged with increased task difficulty. Cognitive resource allocation must be considered a research topic at the present time. Therefore, its inclusion in the LSOTS will be modularized, as was discussed for the trainee model. This will enable the LSOTS to be used while information is being gathered on the best design for resource allocation assessment.

The use of the cognitive allocation strategy for the LSO task was discussed recently by Chatfield (1981) and an example was given. He suggested that the LSO waving task could be combined with the MOVLAS procedure. The lags and leads in MOVLAS position changes relative to glideslope changes could be used as a measure of cognitive capacity. For example, an LSO trainee, when required only to engage in MOVLAS tracking, may be able to track the glideslope performance of the aircraft very accurately with his manual input to the MOVLAS system. However, when he is tasked with waving (making voice calls to the pilot) while he is simultaneously engaged in MOVLAS tracking, the decrement in his MOVLAS tracking performance would be considered a measure of the extent to which his cognitive resource capacity was overburdened. When the LSO trainee had sufficient practice on both tasks so that he became "automatic" on either or both tasks, then his MOVLAS tracking performance would approach that achieved when waving was not required. This would be evidence for advancing the trainee to a new level in the LSO training program or for increasing task difficulty by including other variables. Other potential task candidates for assessing cognitive overload in the LSO context are recall of the aircraft side number or fuel state, response time to a change in the deck status light, failure to lower right arm on clear deck, and decrement in memory of recent approach characteristics.

The issue to be addressed by a development module for cognitive resource allocation is the cost/benefit of this procedure. How much training efficiency is gained by using information from the resource allocation module to improve the decisions of the curriculum control? And, does that gain justify the cost of developing the module.

Artifical secondary tasks used for assessing cognitive resource allocation must not detract from the learning of the primary (LSO) task. In the examples given above, all the tasks must be learned by the LSO and therefore, even if two of the tasks did interfere, it is to the benefit of the trainee to learn both tasks. Other methods of cognitive resource allocation assessment, however, involve secondary tasks, such as reaction time, or signal detection, which are not associated with the primary task of being an LSO. The use of secondary tasks which are not part of the LSO repertoire should be viewed with skepticism. In that case, the cost of a module for cognitive resource allocation is determined not only by the dollar cost in developing the module but by the possible interference with training that could be associated with the secondary (non-LSO) task.

In summary, the outcome of the curriculum control is to specify the most beneficial instructional unit, task or scenario to be trained. It also provides adaptive control of task difficulty so that each trainee is challenged enough to stimulate his maximum growth as an LSO. The variety of variables and the range of difficulty of the combinations of the variables which are envisioned for the LSOTS must be sufficient to challenge even the most experienced LSOs. Therefore, curriculum control module will be able to generate tasks and scenarios over a very wide range of LSO experience, from the initial Phase I School student to the most senior CAG or Staff LSO.

SCENARIO GENERATOR. Development of the scenario generator of the LSOTS was one of the primary objectives of the companion contract in this program (Hooks and McMurry, 1981). The scenario generator is tasked with implementing the decisions about task scenarios which are generated by the curriculum controller.

In an operational LSOTS the scenario generator would access the data base for the variables (and their values) to be included in the assigned task. The scenario generator also would contain the top-level information for creating scenarios that are consistent with an instructional strategy and the length of a training session. An aircraft recovery of 20 planes, for example, might be one scenario equivalent to one session for a trainee. The scenario generator would have resident within it, or would derive from the data base, information to generate a cohesive scenario throughout the 20 plane recovery. Therefore, variables such as weather, pitching deck and type of operations would be constant (or at least fairly consistent) within that recovery scenario. Proceeding to higher frequency events, the scenario generator again would establish an appropriate mix of aircraft types and would organize them in some realistic seqeuence for the recovery scenario. Similarly, the scenario generator would determine and organize appropriate sets of aircraft approach profiles and other primary variables to promote the training objectives of the session.

In summary, the scenario generator developed by Hooks and McMurry (1981) will receive information from the curriculum controller about what is to be trained next and what level of difficulty is appropriate. It will take information from the knowledge base (or data base) to generate the appropriate scenarios, both for the training session as a whole and for each approach or instructional unit within the training session.

PILOT/AIRCRAFT MODEL. As stated previously, the pilot/aircraft model w s developed by Hooks and McMurry (1981). That technical report should be considered a companion volume with the present report.

The primary purpose of the pilot/aircraft model is to simulate the behavior of the pilot/aircraft system during final approach to carrier landing. It is the combination of pilot response, aircraft response, and environmental influences that results in the aircraft dynamics observed by the LSO. Certain pilot characteristics such as over-controlling or under-controlling deviations from the glide slope will be included in the LSOTS both as an instructional variable and as a background variable contributing to the normal variability during simulated recoveries. Dimensions upon which pilots may differ are discussed in more detail in Hooks and McMurry (1981). The pilot/aircraft model will provide simulation of a range of aircraft types and pilot skill and responsiveness levels, so that the LSO trainee can learn how to deal with these variables.

One of the most important functions of the pilot/aircraft model will be to define and generate sequences of aircraft deviations from the optimum approach. Common sequences of deviations, or approach profiles, contribute to certain key concepts for learning the LSO task. Hooks and McMurry, (1981) identified families of approach profiles that could be grouped into a categories such as "come-down." This family of approach profiles defines a key concept to be learned (see Appendix C). It provides a basis for scenario generation for teaching important LSO skills such as avoiding the potentially dangerous situation of a "come-down in close."

The pilot variables, aircraft variables and approach profiles reflected in the pilot/aircraft model will "drive" the carrier approach simulation in support of training in the LSOTS.

VOICE SYSTEM. The benefits to be obtained from a voice-interactive simulation can be described with reference to the procedures used in the LSO Reverse Display. In that system, an LSO trainee may give a particular voice call to the human pilot flying the simulator. Additionally, the LSO instructor listens to the trainee's voice call and evaluates whether or not the call was correct. Two individuals are required to support the training of the LSO. They listen to the same voice call for different reasons; one to fly the aircraft and the other to evaluate of the trainee's performance.

In the LSOTS, by contrast, the pilot can be replaced by a pilot/aircraft model, and the instructor can be replaced (or supported) by an instructor model. When a trainee gives a voice call in the LSOTS, the computer speech recognition system will recognize the trainee's speech and pass the information to two places: (1) to the pilot/aircraft model for real-time interaction on the simulated approach, and (2) to the performance measurement and evaluation system for subsequent evaluation of the trainee's performance.

The voice system, therefore, performs an important function in the LSOTS. The accuracy requirement will be extremely high and the demand for real-time interaction places a high priority on rapid processing. The requirement for high recognition accuracy stems from the short duration (about 30 seconds) of the critical interaction between the LSO and the simulated pilot. There isn't time for "say again."

An overall index for accuracy is difficult to specify. One of the problems with accuracy indicies is their lack of precise definition. For example, most manufacturers will claim that their speech recognizers attain 99% accuracy. In actual application, however, the numbers are considerably less (see McCauley and Semple, 1980; McCauley, Root and Muckler, in preparation). What is needed is accurate system response, sufficient for training effectiveness. Current speech recognizers which are based on principles of acoustic pattern matching are unlikely to approach 99% recognition accuracy in the LSO training environment. System response accuracy, however, may attain very high levels if sufficient committment is made to the development of an intelligent "understanding" system. This understanding software would make extensive use of task variables (changing real-time with the approach) and models of expected LSO behavior to determine appropriate system (primarily pilot/aircraft model) responses. All the available information in the LSO training situation should be used to generate the appropriate system response, not just the acoustic pattern produced by the trainee's speech.

This extensive processing must be accomplished rapidly, because of the pace of the LSO task. While the present authors are unaware of any data on pilot response time to LSO calls, we would estimate that a pilot probably begins responding to an LSO call approximately one second of the call completion. This response time distribution would be skewed, so that one second would be somewhat of a minimum time for responding, and considerably longer time could be taken if the pilot were attending to some other variable at the time of the call. The voice subsystem should be capable of recognizing the LSO call rapidly enough so that the pilot/aircraft model can begin to respond to the LSO call within approximately one second.

Minimizing voice training time is another important objective for the voice system in LSOTS. LSOs have a large number of task variables to be presented to them in training, as indicated by the data base presented in Appendix C. Some practice on the calls themselves is worthwhile to the LSO trainee. But the practice time on enunciating the LSO calls will have some tradeoff with actual training time. The vocabulary size and characteristics for the LSOTS can be described intially by the common LSO calls given in the LSO NATOPS. The vocabulary size represented by NATOPS calls is not particularly large. A substantial number of other calls, however, are frequently used by

LSOs. These are the so called "non-standard" calls, and some of them may need to be included to give a full range of calls and to achieve user acceptance.

One of the more interesting problems for the voice system in the LSOTS will be to differentiate between LSO calls that differ only in emphasis and inflection, such as "POWER" and "POWER!!" Voice emphasis and inflection are used by LSO's to transmit meaning to the pilot. Slight differences in inflection tend to connote different requirements in the magnitude of correction required. However, these nuances of inflection may not be necessary to achieve an effective LSO training system. A voice system capable of very accurate recognition of the standard NATOPS calls and a few of the commonly-used non-standard calls would be sufficient for an effective LSOTS. Variability in inflection and emphasis may be dealt with by voice data collection at pre-defined levels of emphasis, and perhaps by transparent voice data collection during simulated approaches.

Speech generation is another function to be performed by the voice subsystem. Speech generation could be accomplished by computer speech synthesis or replay of digitized speech. The speech generation functions within the LSOTS will simulate transmissions to the LSO from the pilot, the air boss and other landing related personnel. Additionally, speech generation will facilitate some instructional functions. Demonstrations of proper techniques, instructional information, or performance feedback information can be given to the trainee using speech generation.

PERFORMANCE MEASUREMENT AND EVALUATION. The performance measurement and evaluation system contains the three primary functions of measurement, assessment and diagnosis. These represent three stages of processing of the raw performance data. In this section, brief discussion of accuracy requirements and performance feedback also will be given.

<u>Performance Measurement</u>. Performance measurement is the basic data pertaining to the behavior of the LSO trainee relative to the task variables to which he is responding, including aircraft dynamics. This performance measurement will require accurate data on the location and rates of change of the aircraft at all times during the approach. These data must be in six degrees of freedom. The aircraft dynamic data will be readily available within the LSOTS because the data are already contained within the system to drive the simulation and display of the aircraft. These data must be time-logged and saved for comparison to any LSO actions, which also will be time-logged.

The performance measures anticipated at the present time include the following: aircraft dynamics in six degrees of freedom; the trainee voice calls; manual actions - wave-off button and cut-light button; MOVLAS movement, continuous RMS error or other measure; post approach description using LSO shorthand terminology. An additional major category of LSO performance measurement will be the managerial/organizational responsibilities of the LSO. They represent decision making outcomes such as recommending to the air boss to rig the MOVLAS, change the lens roll angle, or cancel flight operations. Many of these performance measures seem to be obtainable through monitoring LSO communications with the air boss or other landing related personnel to transmit a recommendation or decision. These measures could be obtained through the voice system, if properly structured, or they could be simulated by some other means such as a dedicated pushbutton panel. The push-button panel option is favored because it is simpler to implement. The important LSO trainee behavior to be monitored here is the decision rather than the speech itself. Also, there is not a time criticality (on the order of less than a second) as there is in the waving task. A pushbutton panel would eliminate the need for an additional vocabulary set and the associated voice data collection. Also, the method of voice communication would be artificial, since the controlling LSO does not transmit these messages over his handset. Often, the back-up LSO or phone talker will communicate messages on behalf of the controlling LSO via other systems such as the 19MC. However, specifying the precise performance measures required will be part of the task in the final development of this system.

Performance Assessment. Performance assessment refers to the outcome of an analysis process based on comparison between the performance measurement results and a set of criteria describing correct or ideal LSO performance. The assessment process should result in the precise identification of all errors or shortcomings in the trainee's performance.

An area of apparent difficulty for the LSO performance assessment system is the development of a complete quantitative model for the criterion behavior of the LSO. McCauley and Borden (in press) have taken the first steps in the development of an LSO waving model. But that model pertains largely to the A-7 aircraft and requires further development and validation before it can be used in an LSOTS as a criterion for performance assessment. This type of criterion must be extended to all aircraft types included in the LSOTS.

One possibility for generating (or validating) the performance criteria is to collect data within the LSOTS itself during its development stages, using highly experienced and highly qualified LSOs. The consistencies in their waving behavior could be measured by the performance measurement system and codified to become the criteria for performance assessment. An added benefit from this criterion development procedure is that any distortions in the simulation process would be accounted for by collecting the criterion data within the LSOTS itself.

Performance Diagnosis. Diagnosis is the third stage of processing under the performance monitor function. The diagnostic function could be considered a separate subsystem, as described by Chatfield (1980), but for purposes of parismony we have chosen to include the diagnostic function within the performance measurement and evaluation system. Diagnosis is a higher level of processing of the performance error information. The diagnostic function serves to integrate errors over time, looking for patterns of errors made by the trainee. When certain consistencies or patterns in errors are detected, these will be reflected in the trainee model as a deficiency in his cognitive structure or processing. This information then would be passed to the curriculum control module for assignment of appropriate remedial measures.

Accuracy Requirement. Accuracy is essential in the performance measurement, assessment and diagnosis functions. Inaccurate measures lead to erroneous performance feedback and degraded training effectiveness. With an adaptive syllabus, accurate performance measurement also is essential for the appropriate selection of tasks and task difficulty. For example, if a performance measurement system were giving erroneously low scores, the trainee model would underestimate the trainee's state of learning, and consequently, the curriculum control would not advance him at an appropriate rate. This type of error obviously would be inefficient in the use of training resources and would be frustrating to the trainee. Design and implementation of an accurate performance measurement and assessment system is difficult in a complex interactive training system. But accuracy is essential for the system to train effectively.

Performance Feedback. At the present time the authors see no reason that performance measurement and assessment need occur in real-time during an approach. However, the first stage of performance measurement may be required in real-time to support the speech "understanding" software. An LSO decision-making model processed in real time could derive expectancies for the trainee's voice calls. This process could be combined with initial performance memasurement, if computer resources were sufficient. Conceivably, the pilot/aircraft model could be interactive with the initial performance measurement so that a trainee's performance early in an approach might affect the response characteristics of the pilot/aircraft model later in the approach. This technique does not seem necessary, however, since an entire final approach will last only about 30 seconds. Performance measurement and assessment could be accomplished between aircraft approaches, allowing brief performance feedback to be given to the trainee after each approach. Because of the continuity inherent in the final approach profile, freezing the approach to provide feedback is not recommended except during a replay. Breaux (1976) found that stopping (freezing) an approach to give feedback was disruptive to students in a precision approach radar task. He found that replay adequately met the requirement for performance feedback.

The details of this brief feedback procedure need to be developed since there is potential conflict between the feedback information and the continuity of the aircraft recovery. The conflict would occur if performance feedback information were to be given to the trainee at the same time that he should be attending to the next aircraft on final approach.

The recommended technique is to make available brief performance feedback information immediately after each approach. The trainee should be allowed to override (eliminate) the feedback. Advanced trainees, particularly, may not want to deal with performance feedback after each approach. A more complex design possibility is to apply different feedback techniques at different stages of training. Early in training, feedback should be more frequent and more extensive. This can be accomplished by providing the trainee with selection options. The trainee should be given the opportunity to select critical parameters, such as glide slope, AOA, power, etc., for observation during a replay. If replay capability is provided between approaches on a recovery, the trainee should be able to select a limited portion of the previous approach, if desired. For example, he could request to see "Replay, display power, angle of attack, range in-close to at-the-ramp."

Performance feedback of a more general nature could be given at the end of the recovery period. This information would pertain to his performance on the recovery as a whole, and replays of particular approaches could be used for instructional emphasis.

TRAINING SYSTEM EXECUTIVE. The training system executive (TSE) is the control mechanism for the other subsystems. Many of the TSE functions are performed by a human instructor in a non-automated training device. An instructor using a training system such as the LSORD, for example, makes all the decisions regarding setup of conditions for the next demonstration or practice approach, he listens to the voice calls given by the trainee, monitors the performance of the trainee, gives the trainee feedback about his performance, and continues to build up internal schema to represent the state of knowledge of the trainee. These LSO instructor functions are representative of the tasks that have been described for the Instructor Model and other subsystems of the LSOTS. The TSE creates priorities, allows subsystems to communicate with one another, and accesses the data base. The TSE not only is imbued with the characteristics of the higher organizational decisions of the LSO instructor model, but it also takes on the responsibility for coordinating the subsystems within the LSOTS. It is both a training executive and a computer system executive. Advances in artificial intelligence may be applicable to this and other subystems of the LSOTS.

TRAINING SESSION EXAMPLE

An attempt will be made to demonstrate the integration of these subsystems by describing an hypothetical training session for an intermediate-level trainee.

An LSO trainee arrives at the facility for a training session and begins by checking with the technician that the system is up and running. (Even better, the system will be so easy to operate that the trainee can initialize the entire system himself). The LSO trainee begins the session by identifying himself. A brief interrogation may be conducted by LSOTS to verify his identity, either by identification number or voice authentication.

The system retrieves the trainee's files, including any required voice reference data. Alternatively, he would bring some record of his voice data, such as on a diskette. The system assesses his current state of training, via the trainee model, and generates (or updates) a training strategy including the objectives for the present session.

If the trainee were new, or had not worked with LSOTS recently, the system would interrogate him (using CRT or speech generation) for appropriate information such as years (months) of experience as an LSO, qualification level, primary aircraft type, aircraft he is qualified to wave, etc. Additionally, the LSOTS has available a substantial data bank on his prior performance in the system. The aggregate of information from these sources is used by the trainee model to infer the trainee's current state of knowledge and skill as an LSO.

The curriculum control uses this information to develop a near-term training strategy, including topics to be covered and aternative pathways for progress, depending on the trainee's performance. The time required for this processing is minimal, avoiding a boring delay before beginning the session.

The curriculum control accesses the knowledge base for the upcoming scenario and communicates with the trainee via the trainee/system interface (CRTs, speech generation, etc.). A briefing is given about his current status in the curriculum and the topics and objectives for this session. This information also is made available at the LSO instructor's station, should he be present. The instructor can request more detailed information about the trainee's past performance at any time. Also, he has the option to override the selected session topics and objectives.

After briefing the trainee (and instructor) on the upcoming session, the system will review recent training topics and provide a warm-up period for "calibrating his eye" and allowing the trainee to accommodate to the LSOTS environment. Voice data collection is conducted if any new vocabulary words are to be used. Instruction on the new topics is given, with an emphasis on demonstration. Key concepts may be communicated by CRT or speech generation. Lengthy reading from a CRT is avoided.

Warm-up, review, instruction and demonstration are followed by the practice session. During the practice session the trainee may be confronted with an entire carrier recovery scenario that would include environmental and task variables that he has encountered previously in LSOTS, as well as new ones that are the focus for the present session.

The scenario generator, taking instructions from the curriculum control and data from the training knowledge data base, initializes all variables for each approach. Control of the approach passes to the simulation/display subsystem in conjunction with the pilot/aircraft model. The trainee has the pickle and phone in hand and observes the aircraft on a night approach. He listens to the CCA controller transmissions, simulated by the speech generation system, and watches the pilot's CCA performance. At 3/4 mile, the trainee hears the pilot call the ball (again, the speech generation system) and takes control of the approach, responding "Roger Ball." For the remainder of the approach any radio transmission (call) given by the trainee will be recognized by the speech recognition system and "understood" by the intelligent software, which will stimulate the pilot/aircraft model to respond appropriately. In the case of a recognition error, the pilot model tends to ignore the LSO input, as a real pilot would. Pilot response characteristics will be dependent on the type of pilot and aircraft that is being simulated. Whether immediate feedback should be given to the trainee regarding the automated recognition of his calls has not yet been determined (see Hooks, Butler, Reiss, and Petersen, (1980).

At the end of each approach, the trainee gives it a grade and description which is recognized by the speech recognition system. Performance feedback is given to the trainee immediately in summary form, using either visual or aural channels, or both. Possibly, the back-up (supervising) LSO is simulated giving a brief comment on the trainee's performance. This could be done through speech generation, i.e. "You should have given that power call just a little earlier, Charlie."

The performance feedback is obtained from the performance measurement and evaluation subsystem, which compares the trainee's performance with a criterion for correct performance. The outcome of the performance measurement and evaluation procedure becomes performance feedback, to the trainee and also is sent to the diagnostic routine, the record keeping module, and the trainee model. The diagnostic routine analyzes the accumulated composite performance data to determine error trends, and this information is passed to the trainee model and curriculum control to prepare review or remedial instruction when necessary.

When the recovery has been completed, a full review of the trainee's performance during the session is given. Specific errors and error trends are identified for the trainee. Strengths and weaknesses are communicated via visual display and voice. This debrief period helps to consolidate the learning from the session. Other sources of information for review are suggested to the trainee, such as pertinent sections of the LSO NATOPS or LSO Training Guide (Erickson, 1978).

Finally, the trainee is given a preview of topics for the next session and additional reading assignments or interaction with the instructor may be suggested. The trainee signs off the system, looking forward to the challenge of the next session which will consist of Marine F-4s on a dark night with pitching deck, MOVLAS, and no tanker available.

SECTION A-II - FUNCTIONAL DESIGN

A2.1 INTRODUCTION

The Instructor Model will be designed to provide the following primary functions:

(1) Estimate the trainee's job-related learning status based on information in the LSOTS data base.

(2) Select the next appropriate instruction based on (1) above.

(3) Generate the learning task scenario for presentation to the trainee based on (2) above.

(4) Evaluate the trainee's performance in learning the task.

(5) Provide feedback to the trainee about his performance.

(6) Record the pertinent performance data.

(7) Provide an interface between the LSOTS and the human instructor.

In addition, the LSO Instructor Model will be designed to provide the following ancillary functions:

(8) Initialize the LSOTS.

(9) Instructor and/or trainee sign-on and access to specific trainee records.

(10) Demonstrate the LSOTS automated operation for the benefit of first time trainees and visitors.

(11) Review of the curriculum and the analysis of trainees' group performance by the instructional staff.

(12) Collect trainee and/or instructor reference data for the speech recognition subsystem.

(13) Provide a "Manual Mode" of LSOTS operation in the event of speech recognition system failure.

(14) Evaluate the strengths and weaknesses of experienced LSOs as well as trainees.

(15) Shut down the LSOTS when it is not required for further operation.

Generally, control of LSOTS functions will be accomplished by the use of the voice channel (speech recognition by the LSOTS for information entry and speech generation for information output). Where this method of man/machine communications is impractical, information entry will be through the instructor's alphanumeric keyboard and output will be the display of alphanumeric information on the primary display and/or the instructor's console CRT.

The function of the LSO Instructor Model will be partitioned into the following modes:

- o Initialize
- o Demonstration
- o Instruction
- o Manual Back-up
- o Off Line

The functional control of the LSOTS within these modes is shown in Table A II-1.

A2.2 DESIGN OF THE INITIALIZE MODE

The purpose of the Initialize Mode is to allow the LSOTS to be powered-up, the internal system selftest to be executed and the date and time to be entered. The Initialize Mode will be initiated automatically when date and time are entered manually through the alphanumeric keyboard of the external console. Entered data will be shown on the external console CRT. On completion of the initialization, a mode select menu will be displayed on the external and instructor's CRTs. Selection of one of the modes "Demonstration", "Instructional," "Manual Back-up," or "Off Line" will be initiated through the alphanumeric keyboard of the instructor's console by entry of either "DEMO-INSTRUCT-MANUAL."

A2.3 DESIGN OF THE DEMONSTRATION MODE

The purpose of the Demonstration Mode is to allow the operation of the LSOTS to be shown to prospective trainees who are unfamiliar with the system. In addition, the demonstration can be used to show official visitors how the system is used for training LSO's and for LSOTS serviceability checking.

The Demonstration Mode will combine audio and visual information which describes the LSO task and the manner in which the LSOTS accomplishes training. It will then display two approaches which are noticeably different in character. Generated speech will be used during each approach to represent communication between the psuedo LSO and the pilot making the

TABLE A-II-1. LANDING SIGNAL OFFICER TRAINING SYSTEM
MODE CONTROL

Mode/Submode →										
Initialize	Performed by Training Device Technician									
Demonstration	Automatic Canned Scenario									
Instructional	Sign-on	Access Records	Select Training	Warm-up/ Review		Instruction/ Teach	OPS-Brief	Practice	Debrief	Sign-off
					Voice Data			Test		
Manual Back-up	Sign-on	Access Records	Select Training	Warm-up/ Review		Instruction/ Teach	OPS-Brief	Practice	Debrief	Sign-off
Offline	Sign-on	Manual Coded Entries Thru External Keyboard								

approach. The pilot's voice will be noticeably different from the LSO's voice. At the termination of the approaches, the LSOTS will automatically debrief the imaginary LSO trainee by playing back the approaches using visual display and generated speech communications. Display freeze and approach path deviation (using video generated cross hairs) will be demonstrated. At the end of the demonstration, the instructor's CRT will show a menu which will allow the selection of further demonstrations or the selection of the "Instructional" or "Manual Back-Up" modes. Through the instructor's alphanumeric keyboard, the words REPEAT-INSTRUCT-MANUAL will be used.

The duration of the basic demonstration is not expected to exceed 7 minutes, allocated as follows:

Description of the LSO task	-	1 Minute
Description of the LSOTS	-	2 Minutes
Two approaches	-	1 1/2 Minutes
Debrief	-	2 1/2 Minutes

Repeat demonstrations will have noticeably different characteristics in terms of aircraft type or environmental conditions or approach profile. Up to ten different approaches will be selected automatically, in a random sequence, from the canned approach profile repetoire.

A2.4 DESIGN OF THE INSTRUCTION MODE

The Instruction Mode is the multi-featured training mode of the LSOTS, and because of its complexity it is functionally divided into sub-modes which are identified as follows:

- o Sign-on
- o Access Records
- o Select Training
- o Warm-up/Review
- o Voice Data Test
- o Instruction/Teach
- o OPS Brief
- o Practice
- o Debrief
- o Sign-off

The sub-modes will be serially self-selecting at completion of the previous sub-mode. The functions within these sub-modes are described in the narrative which follows.

Sign-On - The instructor and/or the trainee are visually requested through the instructor's CRT, to enter their social security numbers through the instructor's console alphanumeric keyboard. The entered data will be shown on the instructor's CRT and subsequently recognized by the system to determine the eligibility of the users. A design option will be voice authentication of eligible users. In the event that the users are ineligible, a message to that effect will be displayed on the instructor's console CRT.

Transfer to the next sub-mode will be made manually by entering the word "CONTINUE" through the instructor's keyboard or by verbal command through the speech recognition system. In the event that user(s) are not eligible, transfer to the next mode is inhibited.

Note that information in regard to eligible users is entered in the "Off-Line" mode.

Access Records - The instructor and/or trainee can review the trainee's training status or the instructor's CRT. The displays will show:

- Trainee's name, rank, and social security number
- Recency of training on LSOTS
- Position in the curriculum at that time
- Performance level - session
  - last N sessions
  - overall

Note that in this sub-mode, access to records will be limited to the individual trainee who has "Signed-On." Further access to trainee records (by individual or class) will be made available to supervisory instructors through the external console in the "Off-Line Mode." The instructors will have a review routine available to them which will allow the data to be temporarily maniupulated to determine for example, a specific trainee's strengths and weaknesses.

Transfer to the next sub-mode will be made manually by entering the word CONTINUE on the instructor's keyboard or by verbal command through the speech recognition system.

Select Training - The instructor and/or trainee can approve the instructional unit to be presented, or opt for training selected from a different part of the LSOTS curriculum by verbally or manually responding to the generated speech questions.

The key concepts and training objectives for the instructional unit to be presented will be shown on the primary display and the instructor's console CRT. The unit to be presented will result from the indexing of the trainee into the curriculum and will be based on the automated curriculum control process of the instructor model.

Normally, the instructional unit will be accepted by the instructor and/or trainee. However, if they wish to override the selected instructional unit, they can do so by saying "Select Instruction Unit #N." In this event, the key concepts of the requested instructional unit are displayed for review by the instructor and/or trainee. The accept/reject process can continue for an unlimited number of instructional units.

If the instructor is present and signed on, he may choose to develop his own training scenario for the trainee. An entry of the words "Special Training" through the instructor's alphanumeric keyboard will produce a special format on the CRT in which the instructor and/or trainee will enter the required training scenario data. This data is maintained only for one session and is not supported by any instruction. On completion of the data entry the "OPS Brief" sub-mode is selected manually by entering the word "CONTINUE" through the instructor's keyboard. Details of the "Special Training" scenarios wi'l be maintained in the system records for future instructional unit development.

Warm-Up/Review - The trainee will be presented with a series of approaches to warm-up and to "calibrate his eye." Up to five characteristically different approaches, will be automatically and randomly presented using aircraft types and environmental conditions consistent with previously received training. Gross performance feedback will be given verbally between successive approaches through the use of generated speech.

Special review scenarios will be presented to trainees who have not used the LSOTS for a substantial period of time. However, for trainees who have used the LSOTS within seven calendar days, the Warm-up/Review scenario will be based on the training received in the last instructional unit.

For first time LSOTS users, the select training, Warm-up/Review and Voice Data Test sub-modes will be by-passed by automatic selection of Instructional Unit #1, which covers the introduction to the LSOTS and is implemented in the Instruction/Teach sub-mode.

After the waving segment of each approach, the LSO trainee will describe the approach using his microphone. (In actual practice, the controlling LSO addresses a book-writer LSO and describes the performance of the pilot/aircraft on the last approach. The book-writer LSO then records the approach description in the LSO logbook). In the case of the LSOTS, the approach description becomes an assessment of the LSO trainee's performance when it is compared to the aircraft's known approach path. Therefore, the approach description will be entered into the performance measurement and evaluation data base. Completion of the waving segment of an approach will be defined as when the aircraft has arrested or boltered or crashed and there are no formal voice communications for a period of 5 seconds. An alternative design is to have the trainee or instructor say a keyword, such as "End Approach."

The approach description segment will begin at that time. Transfer to the next sub-mode is automatic on completion of the Warm-up/Review scenario.

Voice Data Test - The acoustical speech patterns, which are required for speaker-dependent speech recognition systems, must be available for test and modification. In this sub-mode, voice data collection of any of the three types of vocabulary words and/or phrases (waving, approach description, and LSOTS control commands) can be automatically prompted and reacquired. The sub-mode is automatically selected in the event of inadequate speech recognition during the conduct of the Warm-up/Review approaches. However, the Voice Data Test sub-mode will be automatically bypassed if the LSOTS assesses that the voice recognition subsystem is operating satisfactorily. Additionally, the Voice Data Test sub-mode will be selectable by the trainee or instructor at any time between approaches.

At the beginning of the reacquisition sequence, the instructor and/or trainee will be asked through generated speech whether they wish to review the confusion status of the vocabulary words and phrases collected so far. If the answer is "no", then the reacquisition process commences. If the answer is "yes", a list of vocabulary words and phrases with their respective discrimination indices will be displayed for 30 seconds or until told to continue. Transfer to the next sub-mode is automatic on completion of the satisfactory reacquisition of the required words and/or phrases.

The Voice Data Test sub-mode can be manually selected at any time an approach is not in progress by entering VOICE TEST through the instructor's alphanumeric keyboard or by verbal request. Alternatively, this sub-mode will be entered automatically when the system detects inadequate discrimination indices. In either case, a list of vocabulary words and phrases and their discrimination indices will be displayed on the primary display and instructor's console CRT. Each word, and/or phrase, can be reaquired by saying the identifying number followed by the word or phrase "N" times (unless more optimal "context" sampling is available). After reacquisition, the discrimination indices will be automatically updated and can be reviewed by the trainee and/or the instructor by reentering the voice test submode. Transfer back to the previous sub-mode may be selected manually or verbally.

The automatic selection of the Voice Data Test sub-mode will occur when the value of the confusion index exceeds some criterion. The value of this criterion must be easily changed in the system, and it should be an item for testing during the acceptance test period.

Instruction/Teach - Audio and visual instructions (shown on the trainee's display) will be presented to assist the trainee in understanding key concepts and training objectives for the selected instructional units. The presentation of the instruction for this instructional unit can be overriden verbally by the trainee or instructor by responding to the LSOTS speech-generated questions.

During this sub-mode, voice data collection of special vocabulary words and phrases, which are unique to the selected instructional unit, are automatically prompted and acquired. This process is done in the operational context whenever possible. The voice data collection includes words and phrases for both the waving and approach description vocabularies.

Instruction and teaching will be presented to the trainee through scenarios with both visual and audio information. It will cover lesson objectives, variables to which the trainee will be exposed, demonstrated proper procedures, interactive "Now you do it" opportunities for the trainee, and reruns with LSOTS visual and verbal feedback (with appropriate instructional features, such as cross-hairs, last safe wave off indicator, etc.).

For Instruction Unit #1 "Introduction to LSOTS" (see note under "Warm-up/Review" sub-mode), the trainee will be taken through a canned scenario which will introduce him to the LSOTS features in addition to being given examples of the type of training the LSOTS will provide him.

During the progress of Instructional Unit #1, the basic LSO waving and approach description vocabulary and LSOTS control vocabulary will be automatically prompted and acquired.

Transfer to the next sub-mode is automatic on completion of the Instruction/Teach scenario.

Note that at the end of the Instruction/Teach sub-mode, the Voice Data Test sub-mode may be automatically reselected by the LSOTS in order to reaquire words and/or phrases which are rated as confusing by the system.

OPS Brief - The instructor and/or trainee will be briefed, using an Air Ops type of display, of the prevailing conditions which will be experienced during the approaches which follow. Variables such as aircraft type, carrier type, environmental conditions, and equipment malfunctions, are typical briefing topics. The brief may include the nominal operating range of important instructional variables. These values can be altered within certain limits by the instructor to tailor the scenarios to the particular trainee or situation. Records of these changes will be kept in the system to support subsequent changes in LSOTS instructional units.

Transfer to the next sub-mode is automatic on completion of the OPS Brief scenario.

Practice - The approaches which relate to the selected instructional unit will be presented on the primary display. Trainee voice data and manual action data (waveoff and cut-light activation) which describes the LSO waving performance for each approach will be collected. Gross error performance feedback will be given to the trainee between successive approaches through the use of generated speech. Visual information can be provided for feedback if it does not interfere unduly with an ongoing recovery scenario.

Both short term and long term performance assessments will be made in this sub-mode. The short term information, such as hook-to-ramp clearance, distance off-line-up, wire #, terminal sink rate, etc., will be shown unobtrusively on the upper part of the primary display immediately after each landing. The longer term or trend data will be shown in a similar manner at the end of each session.

Generated speech outputs from the LSOTS will provide direct and background communications from other aircraft pilots, the air boss, and other recovery personnnel. After each approach, the trainee will verbally describe the approach, using his microphone in an identical manner to that for approach descriptions in the Warm-up/Review sub-mode.

Transfer to the next sub-mode will be made automatically on completion of the last approach description.

Debrief - The instructor and/or trainee will be presented with a generated speech narrative of the diagnosis of the trainee performance for the recovery session. Best case and worst case approaches which were waved by the trainee will be replayed to support the diagnosis. Display/freeze and approach path deviation measurements (using video-generated cross hairs) will be available to the instructor and/or trainee by verbal command or manual selection.

The key concepts and training objectives for the session will be restated during the debrief and the LSOTS will state whether these have been accomplished by the trainee.

On completion of the diagnosis/replay phase of the debrief, the LSOTS computed scores for each approach and the overall grade for the session (or recovery) will be presented. Suggested improvements in performance, reading, and preparation for the next training session will be made at this time.

The computed approach scores and the session grade also will be displayed on the instructor's console. In the event that an instructor has signed on, the approach scores and session grade can be manually entered into the record system by the instructor at his console keyboard. System records will save both the computed scores and the instructor's scores. Pertinent remarks made by the instructor for record purpose can be entered through the instructor's keyboard at this time.

Transfer to the next sub-mode will be made automatically on completion of the debriefing.

Sign-Off - The instructor's console CRT will display a menu which will allow the instructor and/or trainee to terminate the session or continue with the next appropriate instructional unit. A verbal or keyboard entry of TERMINATE will terminate the session. A verbal command or keyboard entry of CONTINUE will commence the continuation sequence by the LSOTS suggesting that the trainee take a coffee break. However, in the event that the trainee displayed deteriorating performance on the last session, it will recommend that he should not commence the next session. A "Terminate" or "Continue" selection menu will again be displayed on the instructor's CRT.

By entering CONTINUE for the second time the LSOTS will automatically sequence to the select training sub-mode.

Note that a TERMINATE or CONTINUE entry will send all the prior session score, grade, diagnostic information and instructor's entered comments into the record system for subsequent access and/or processing.

The information which is passed into the record will be available for hard copy by adding the word "Copy" after the first "Terminate" or "Continue" entries.

The duration of each instructional session is not expected to exceed 60 minutes, allocated as follows:

o "Sign-On" through "Instruction/Teach" - 20 Minutes

o "OPS Brief and Practice" - 30 Minutes

o Debrief and Sign-Off" - 10 Minutes

A2.5 DESIGN OF THE MANUAL BACK-UP MODE

This mode will be used in the event that the speech recognition subsystem is inoperative. When an instructor is available at the instructor's console he will act as the pilot of the approaching aircraft when a change from the programmed approach is required by the trainee's voice call. The trainee will use his speech channel for direct communication with the instructor's console. The instructor's console will be fitted with appropriate controls which will enable him to make incremental changes to the preprogrammed aircraft's approach profile in response to the trainee's waving commands. There is no requirement for realistic controls, such as stick and throttle, as the instructor will <u>not</u> be required to continuously control the approach. He only needs <u>the</u> capability to make minor adjustments in the approach, and initiate a response to LSO trainee calls, including waveoff. Approach description data will be entered through a small keyboard specifically designed for that purpose.

Effective training can still be accomplished in the Back-Up mode when the instructor is not available. Although voice calls will not be possible, the trainee can keep the aircraft off the ramp by using the CUT lights for power and the WAVEOFF lights. This procedure provides legitimate practice for EMCON or radio failure conditions. The trainee will enter the approach description through the special keyboard mentioned previously.

The Manual Back-Up Mode has similar sub-modal operation to the "Instructional" sub-modes as follows:

Sign-On

Access Records

Select Training

Warm-Up/Review

Instruction/Teach

OPS-Brief

Practice

Debrief

Sign-Off

The absence of LSOTS speech recognition in the Manual Back-up Mode manifests as follows:

Sign-On - No difference from "Sign-On" in the Instructional Mode, except that voice authentication and the verbal function to "Continue" is not possible.

Access Records - No difference from "Access Records" in the Instructional Mode.

Select Training - The task approval or optional section of the alternative tasks must be made using the menu display and keyboard at the instructor's console.

Warm-Up/Review - The instructor provides the pilot's voice response and makes incremental change to the aircraft's approach profile in response to the LSO waving commands. The instructor also provides gross performance feedback to the trainee between approaches, and records the approach description by keyboard input.

Instruction/Teach - No difference from "Instruction/Teach" in the Instructional Mode except that the instructor must provide the aircraft pilot's voice response and make incremental change to the aircraft's approach. If the speech generation system is down, the instructor must provide the voiced portion of the instruction and demonstrations.

Practice - The instructor provides the pilot's voice response and makes appropriate inputs to the programmed approach profile. The performance assessment system is assumed to be operative, but it will require the instructor to manually enter the code for the trainee's waving commands (plus their time of onset) and approach description. This could be done by freezing the replay at the time a call was given.

Debrief - No difference from "Debrief" in the Instructional Mode.

A2.6 DESIGN OF THE OFF-LINE MODE

This mode is the administrative mode of the LSOTS and does not require trainees to be present. The mode is intended to provide approved personnel access to trainee records, curriculum and software program contents. To provide control of the data access and the extent to which it can be changed, only specified people will be able to enter and change specific data files. In general, the following access and change structure will be provided through the external console's keyboard and CRT.

Operational Personnel

Training Supervisor LSO - All trainee and class records, all instructor's records, all parts of the curriculum, scenario codes, standard scenario variables, performance assessment criteria, diagnostic rationale, and LSOTS instruction unit utilization data.

Instructor LSO - All trainee and class records, all instructor's records, all parts of the curriculum, scenario codes, standard scenario variables, performance assessment criteria, diagnostic rationale, and LSOTS instructional unit utilization data.

Note that the access provided to training supervisory and instructor LSOs will enable them to delete and add trainee's names, identification, and pertinent training status data.

Instructional Technology Personnel

Training Analyst - All parts of the curriculum, scenario codes, standard scenario variables, performance assessment criteria, diagnostic rationale, instructional unit utilization, knowledge base status, student model status, speech recognition vocabularies and their confusion indices, and training statistics.

Systems Analyst - Every software instruction module in the system at the program level language, or higher level language when available.

Note that the access provided to the training and systems analyst provides them with overall technical control of the system. Software program changes should be approved by the LSO Training Model Manager and will be made by the systems analyst.

Maintenance Personnel

Training Device Technician - Same as for Training/Systems Analysts except that his identification code will preclude him from making software program changes.

It is an objective of the functional design of the LSOTS to enable the Off-Line mode to be executed as a background program concurrently with the normal execution of LSOTS training. The practicality of this objective is dependent on the computing capacity of the hardware chosen for the LSOTS implementation.

SECTION A-III - SYSTEM DESIGN

A3.1 INTRODUCTION

The LSO Instructor Model will be designed according to the following system concepts:

(1) Modular organization of "training unique" functional software.

(2) Suitable for implementation on any current, commercially available computing hardware and peripheral equipment.

(3) Compatible interface with ship's LSO platform controls and displays.

(4) Compatible interface with a production visual scene system used for the display of approaching and landing aircraft.

The system organization is depicted in Figure A-III-1. The executive program, called the Training System Executive (TSE), provides the communications between the host computer operating program and the various major system elements which comprise the LSOTS. These will be called:

Instructor Model

Human Instructor Interface

Trainee Interface

Voice System

Pilot/Aircraft Model

The Pilot/Aircraft Model has been developed under a separate contract and is documented in Technical Report NAVTRAEQUIPCEN 80-C-0063-1 "Pilot Behavior Models for LSO Training Systems," by Hooks and McMurry (1981). That report is cited often in this section to ensure the design continuity of the LSOTS.

The software program modules used in the system organization are shown diagramatically in Figure III-2 and are identified as follows:

Curriculum Control

Performance Measurement and Evaluation Unit

Training Development Module

Trainee Interface

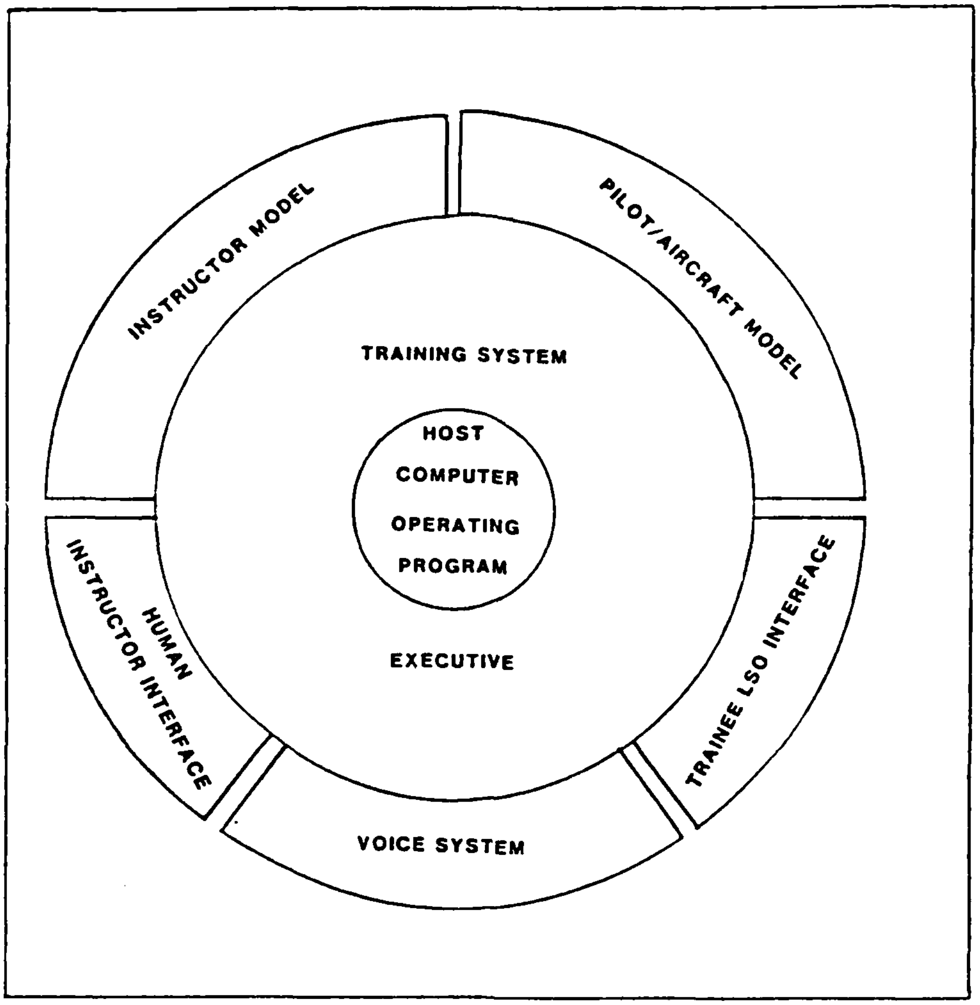

Figure A III-1. Overall LSOTS Major System Element Relationships

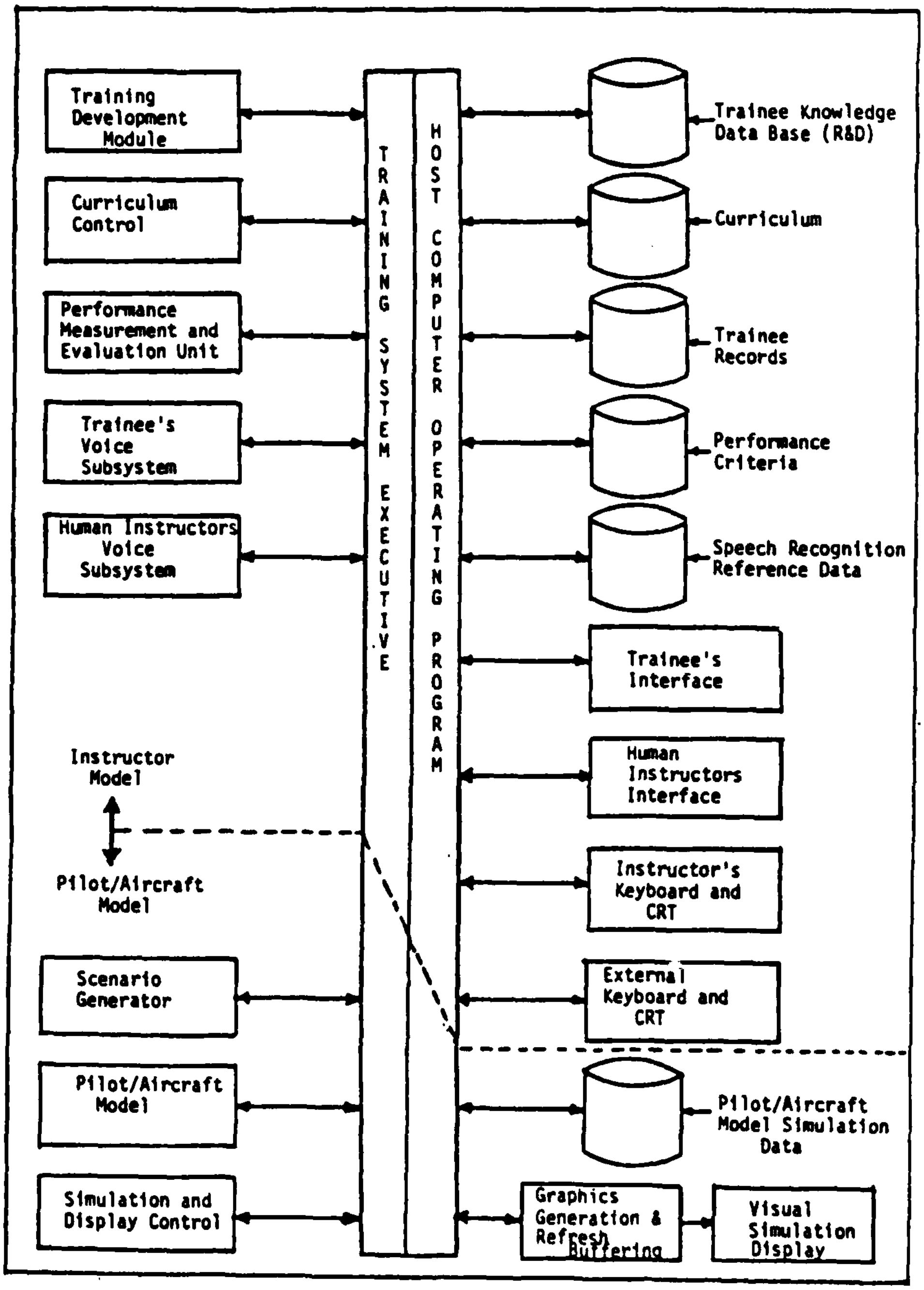

Figure A III-2. Major Program Modules of the Functional Software Organization

Human Instructor Interface

Speech Recognition Subsystem

Speech Generating Subsystem

Training System Executive

These major program modules will be supported by long term data files which will be identified as follows:

Curriculum

Trainee Records

Performance Criteria

Speech Recognition Reference Data

Trainee Knowledge Data Base

Temporary data files ill be established for each training session as follows:

- Aircraft approach profile information for subsequent playback.
- Communications from the trainee to the approaching pilot(s).
- Recovery management communications from the trainee to operational personnel.
- LSOTS-generated speech to the trainee and/or instructors.
- Approach descriptions by the trainee.

Note that the training development module and trainee knowledge data base will be designed into the basic system to gain knowledge of the trainee and instructor behavior while the LSOTS is in use.

A3.2 MAJOR PROGRAM MODULE DESIGN FEATURES

Curriculum Control (CC)

The CC will make decisions to determine the next instructional unit that should be presented to the trainee. The decisions will be based on the following information:

- o Previous position of the trainee in the curriculum
- o Human instructor inputs and recommendations
- o Trainee's past performance on the LSOTS
- o Experience level of LSO trainee
- o Trainee model inferences about the state of knowledge of the trainee (initially for recording purposes only)

A flow diagram for the CC is shown in Figure A III-3. It functions in the foreground between the select training and warm-up/review sub-modes.

The primary purpose of the CC is to provide the LSOTS with automated adaptive syllabus logic. The CC takes information from the performance records and makes decisions about what information, instruction, or practice problems should be given to the trainee.

The initial CC program will be predicated on a linear (as opposed to a branching) curriculum as determined by the training analyst. The CC will index the trainee into the curriculum such that the difficulty level of training will be progressively increased as the trainee continues through the LSO course.

The CC also will be designed to accept a second version of program software which will adapt the sequence and difficulty of the instructional units contained in curriculum so that the trainee may proceed at his own pace. This updated self organizing program will be predicated on the collection of data about the progress of initial students exposed to the LSOTS.

The CC basic design also will provide for a third version of program software which will include estimates of cognitive resource allocation to assist in determining: 1) when a trainee is ready to continue through the curriculum and/or; 2) to be exposed to additional variables or levels of variables which increase task difficulty.

The purpose of designing the CC to accommodate different software configurations is directed at optimizing its design based on the R&D functions allocated to the trainee model. The development scheme is shown in Figure A III-4 and discussed further under "Training Development Model."

Irrespective of the progressive development of CC software, note that when the CC has selected a specific instructional unit, it can be overridden by the instructor and/or trainee by selecting another instructional unit number.

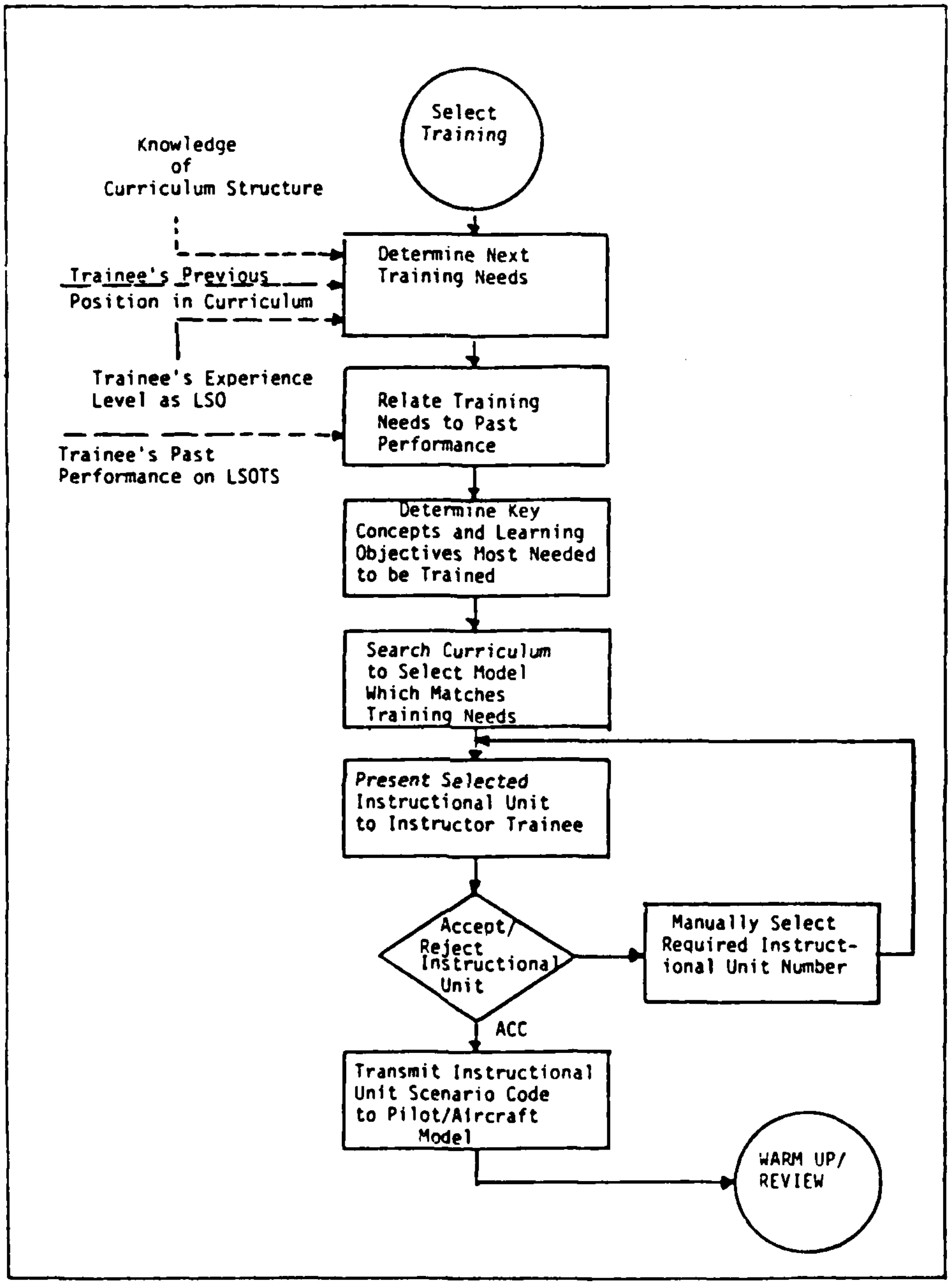

Figure A III-3. Basic System Flow For Linear Curriculum Control

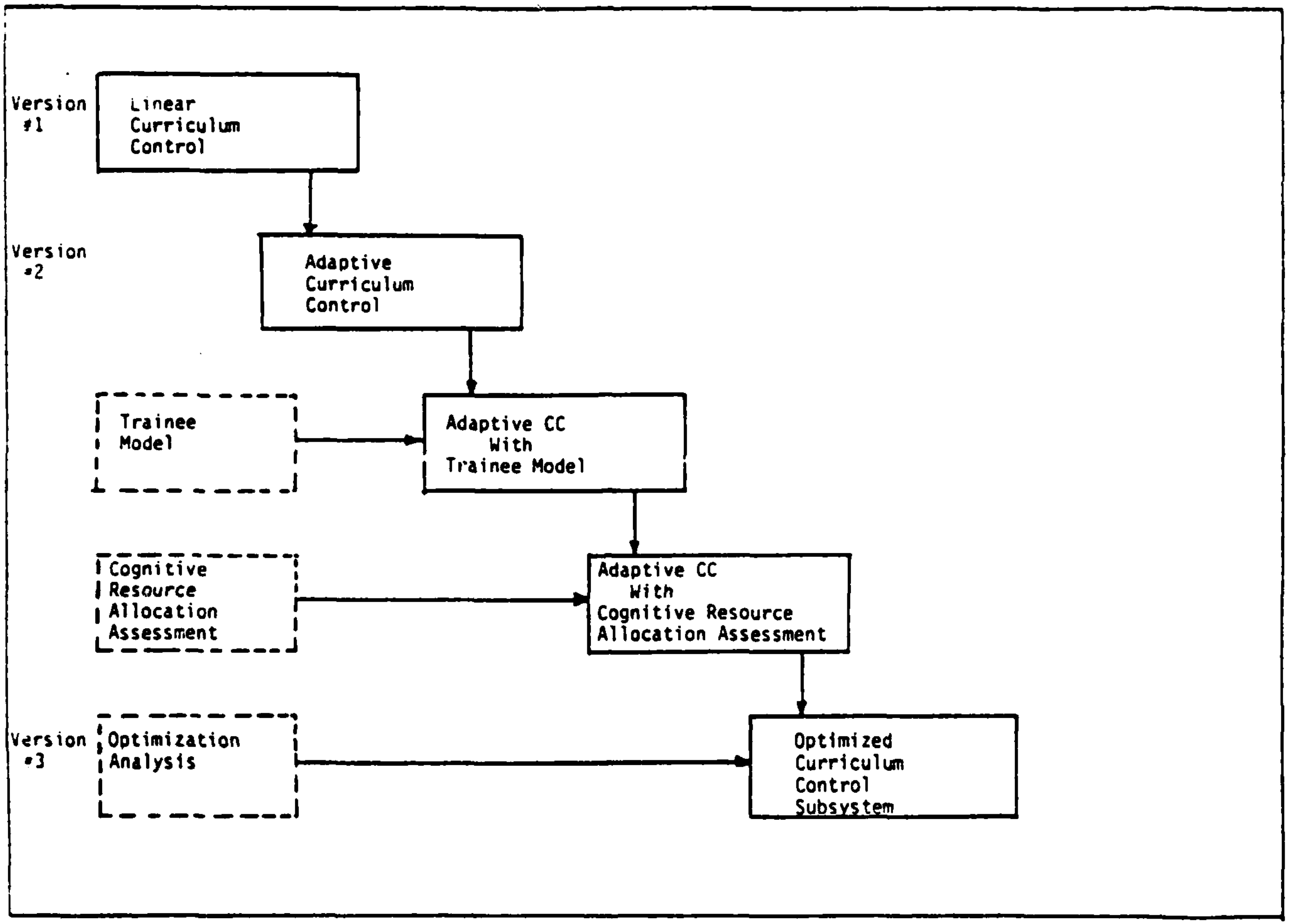

Figure A III-4. Software Program Development for Curriculum Control

Common to all three versions of software is the scenario code which is used by the pilot/aircraft model to generate the visual simulation and associated sound effects. The instructional unit is transferred from the CC to the pilot/aircraft model by the training system executive (TSE). Furthermore, note that in Figure A-III-3 trainee and curriculum file information is transferred from the respective long term data bases into the CC by the TSE.

Performance Measurement and Evaluation Unit (PME)

The PME unit will measure, evaluate and provide diagnostic information about the trainee's performance in the following areas:

- LSO calls relative to the aircraft approach positions and rates.
- Post-approach grade and approach description relative to the aircraft approach positions and rates.
- Recovery information, i.e., boarding rate, bolter rate, accident rate, wire frequencies, line-up and sink rate at touchdown.
- MOVLAS positioning.
- Recovery management decisions and responses to equipment malfunctions.
- Diagnosis of trends of strengths and weaknesses of trainee's performance.

Measurement information will be gathered on continuous and discrete event variables shown in Table A-III-1. This information will be time logged and temporarily stored during each approach for subsequent processing between approaches and after each recovery.

Waving performance evaluation after each approach or recovery will be predicated on a quantative model of the LSO waving calls, a sample of which is shown in Figure A-III-5. The waving model described in McCauley and Borden (in press) is a starting point for automated measurement of waving criteria. However, it was developed for the A-7 aircraft, and must be expanded to account for LSO strategies and techniques appropriate to other fleet aircraft. Additionally, some of the timing parameters of the model must be developed, such as the optimum time to wait (under different circumstances) after giving a call in order to determine whether a sufficient pilot correction has been initiated. Finally, preliminary data from experienced LSOs will be required to specify an exhaustive set of waveoff criteria.

Measurement and evaluation of the LSO trainee's approach description in the LSOTS will require that a standardized set of descriptors be defined as the criteria. Decisions about the acceptability of alternative

TABLE A III-1. CANDIDATE VARIABLES FOR LSOTS PERFORMANCE MEASUREMENT AND EVALUATION SYSTEM

LSO ACTIONS

Waving Calls
Approach Description and Grade
Wave-off
MOVLAS Positioning
Recovery Management Decisions

(examples: rig barricade
rig MOVLAS
target 2-wire
check ship's trim)

APPROACH DYNAMICS

Aircraft X, Y, Z Velocities and Position on Approach
Aircraft Roll, Pitch, Heading, AOA Rates and Angles
Power Setting (Fuel Flow)

APPROACH TERMINATION

Calculated Minimum Wave-off Point
Hook Touch Down Point (X,Y)
Wave-off
Bolter
Accident

RECOVERY DATA

Carrier Type
Type of Operation
Number of Aircraft to be Recovered
Aircraft Type
Side Numbers
Pilot Identification
Fuel Remaining
Plane Guard Available
Availability of In Flight Refuelling
Availability of Divert Field
Unusual Conditions of Pilot/Crew
Status of Deck (Clear/Foul)
Restricted Communications (EMCON/ZIPLIP)
Wires Missing

(Cont.)

TABLE A III-1. CANDIDATE VARIABLES FOR LSOTS PERFORMANCE MEASUREMENT AND EVALUATION SYSTEM (continued)

ENVIRONMENTAL

- Wind Direction
- Wind Speed
- Deck Motion
- Ship Trim
- Ship Turn
- Visibility
- Horizon
- Ceiling
- Ambient Light
- Burble
- Approaching Aircraft Noise

AIRCRAFT EQUIPMENT STATUS

- Position of Gear, Hook and Flaps
- Radio Frequency Tuned
- Light Configuration
- Malfunction/Failures
- APC or Manual
- Direct Lift Control Operating

SHIPS EQUIPMENT AVAILABILITY

- ACLS
- FLOLS
- MOVLAS
- SPN 42
- SPN 44
- PLAT
- LSO HUD
- WOD
- Class
- Hook-To-Ramp Indicator
- Deck Lighting
- Arresting Gear
- Barricade

NOTE

All variables used in the LSOTS Simulation are candidate variables for performance measurement. See Appendix D, Table D-2, and Hooks and McMurray (In Press) Tables E-9 through E-11.

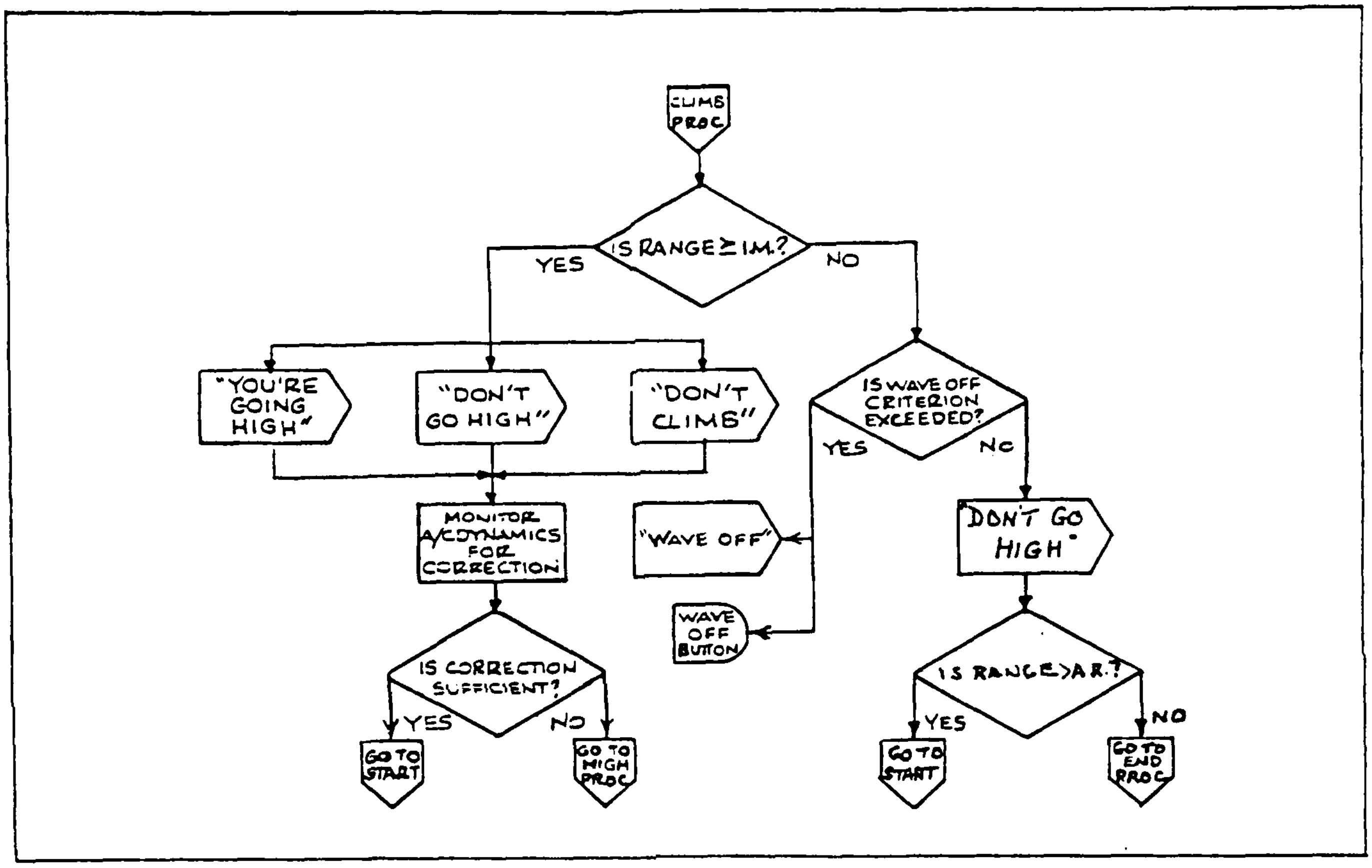

Figure A III-5. Climb Procedure for LSO Wavining Model desc.iptions, such as "not enough power" and "ease gun" should be made by the LSO Training Model Manager. The relationship between standardized approach descriptions and aircraft approach dynamics (accounting for aircraft type and other variables) must be codified to serve as criteria for automated performance measurement and evaluation.

Furthermore, the continuous calculation of the wave-off point and the action which the LSO trainee takes as the aircraft approaches this point are important performance measurement processes which must be provided in the PME. Caution must be advised here, because there is more than one waveoff point, depending on the purpose of the waveoff. A technique waveoff would have a minimum criterion of enabling the aircraft to clear the ramp. A foul deck waveoff due to an aircraft in the landing area must be given sooner. The minimum criterion here might be for the hook to clear the deck by a minimum of 20 feet. "Intelligent" calculation of the waveoff point, depending on its purpose, will be required.

Explicit performance measurement processes must be developed for all aspectds of LSO performance. A list of candidate performance measures is shown in Table A-III-2. Criteria for recovery management decisions, such as rigging the barricade, using MOVLAS, checking ships trim, targeting the two-wire, cancelling operations, etc., need to be developed by subject matter experts. In all of the cases described above, a comparison between the measurement of the trainee's actions in these situations and the LSO performance criteria will provide scores which reflect the performance of the trainee. The weighting and combining of these scores will provide the evaluation grade of the trainee for each approach and recovery, and will be the basis for diagnostic inferences about his strengths and weaknesses.

Further elaboration of performance measurement processes was contributed by the staff of the LSO Training Model Manager, and is presented in Table A-III-3.

Diagnosis of performance will be a higher level of processing (above evaluation) which will integrate errors and look for patterns of errors made by the trainee. Consistant error tendencies will be reflected in the trainee model as a deficiency in the cognitive structure or processing by the trainee (see Chatfield, et al., 1981). In later versions of curriculum control software, this diagnostic information will be used to recommend trainee remediation.

A flow diagram for the short term operation of PME is shown in Figure A-III-6. It functions in the background to evaluate each approach made with the *warm-up/review, instruction/teach and practice sub-modes*. The processing of data to determine the trainee performance in respect to criterion behavior is not made until after the completion of each approach. On completion of the processing, the approach will be evaluated for short term feedback to the trainee prior to commencement of the next approach. Information about each approach performance evaluation will be temporarily stored for post recovery debriefing.

TABLE A III-2. LSOTS CANDIDATE PERFORMANCE MEASURES

AIRCRAFT CONTROL

Aircraft Perturbations versus LSO's Waving Calls
LSO Waving Calls versus Waving Model
LSO Actions (Wave-off/Cut) versus Waving Model
*LSO Input to MOVLAS versus MOVLAS Model

APPROACH DESCRIPTION AND GRADE

*LSO Descriptors versus Approach Descriptor/Grade Model

LANDING SYSTEM OUTCOME

Boarding Rate
Wire Frequency by Number
Bolter Rate
Accident Rate by Type

RECOVERY MANAGEMENT

Request Checking of Ship's Trim
Request Adjustment of Glide Slope Angle
Recommend Change in Wind-Over-The Deck (Speed and/or Direction)
Recommend Setting Arresting Gear for Specific Aircraft Weight
Request Checking of FLOLS Calibration/Stabilization
Request Checking of FLOLS for Specific Aircraft Type
Monitor Hook-To-Ramp Indicator for Prescribed Distance
Request Checking of SPN 42 Radar Calibration (CCA Calls, Mode 1)
Recommend Rigging of Barricade
Recommend Rigging of MOVLAS
Recommend Diversion to Alternate Field (Bingo)
Recommend Diversion to Tanker Aircraft
Check LSO Position for Minimum Operational Equipment
Allocate Platform Personnel Duties

*NOTE:

The MOVLAS model and approach descriptor/grade model define the correct LSO behavior for these functions. Both models have yet to be developed.

Table A-III-3. Performance Measurement System Elaboration for LSOTS

	AREAS	STUDENT OUTPUT	COMPARED TO	RMKS	WAYS TO EXPRESS
1.	Perception	Approach Description	Pass Flown	Error go to LSO trend analysis	Rate (%)
2.	A/C Control and Strategy	LSO Voice calls/no calls	Pass Flown and LSO Model	Proper or improper calls for that approach	Rate and Type
3.	A/C Control and Strategy	LSO Voice calls/ no calls	Perceived Pass and LSO Model	Proper or improper logic used by LSO	Rate and Type
4.	Recovery Man	Calls to Boss, AIR OPS, CATTC, etc.	Existing unacceptable conditions	Conditions and solutions known/ unknown by LSO	"On/Off" and time to discover/correct
5.	Perception	MOVLAS Positioning	Glideslope flown	Errors=Perception error or cognitive resources maxed out	Time "off" A/C and degree (balls)
6.	Recovery Man	Boarding Rate	-	Gross LSO Performance Indicator	Percentage, excluding Foul Deck Waveoff
7.	Recovery Man	Crash Rate	-	Gross LSO Performance Indicator	Percentage and Dollar Cost
8.	Recovery Man	Efficiency Rate Achieved	Efficiency Rate Programmed	Gross LSO Performance Indicator; "Small Picture" efficiency	Ratio? Type See Rmks
9.	Perception and A/C control strategy	Calls and Pass Description	A/C Terminal Dynamics and Position	Importance increases in Pitching Decks	See rmks
10.	Recovery Man	Landing Performance score achieved	Landing perf. Score "programmed"	"Big Picture" Efficiency	See rmks
11.	Perception	Wave-off/no wave-off	Optimum wave-off position	Type 1 & 2 signal detection performance	Numbers of both types

Remarks:

1. Efficiency Rate = of those approaches programmed to be unacceptable, how many did the LSO "fix" by intervention compared to those approaches programmed to be acceptable in which LSO intervention resulted in an unacceptable approach. e.g.: Programmed bolter turned into a trap, relative to programmed trap turned into a bolter.

2. Aircraft Terminal Dynamics = desired/applicable parameters, wire, line-up position, longitudinal attitude (nose up/down), roll (in degrees), sink rate (FPS).

3. Landing Predictor Score (LPS) = See Brictson, Burger, and Wulfeck (1973). Note that LPS may be redundant with efficiency rating.

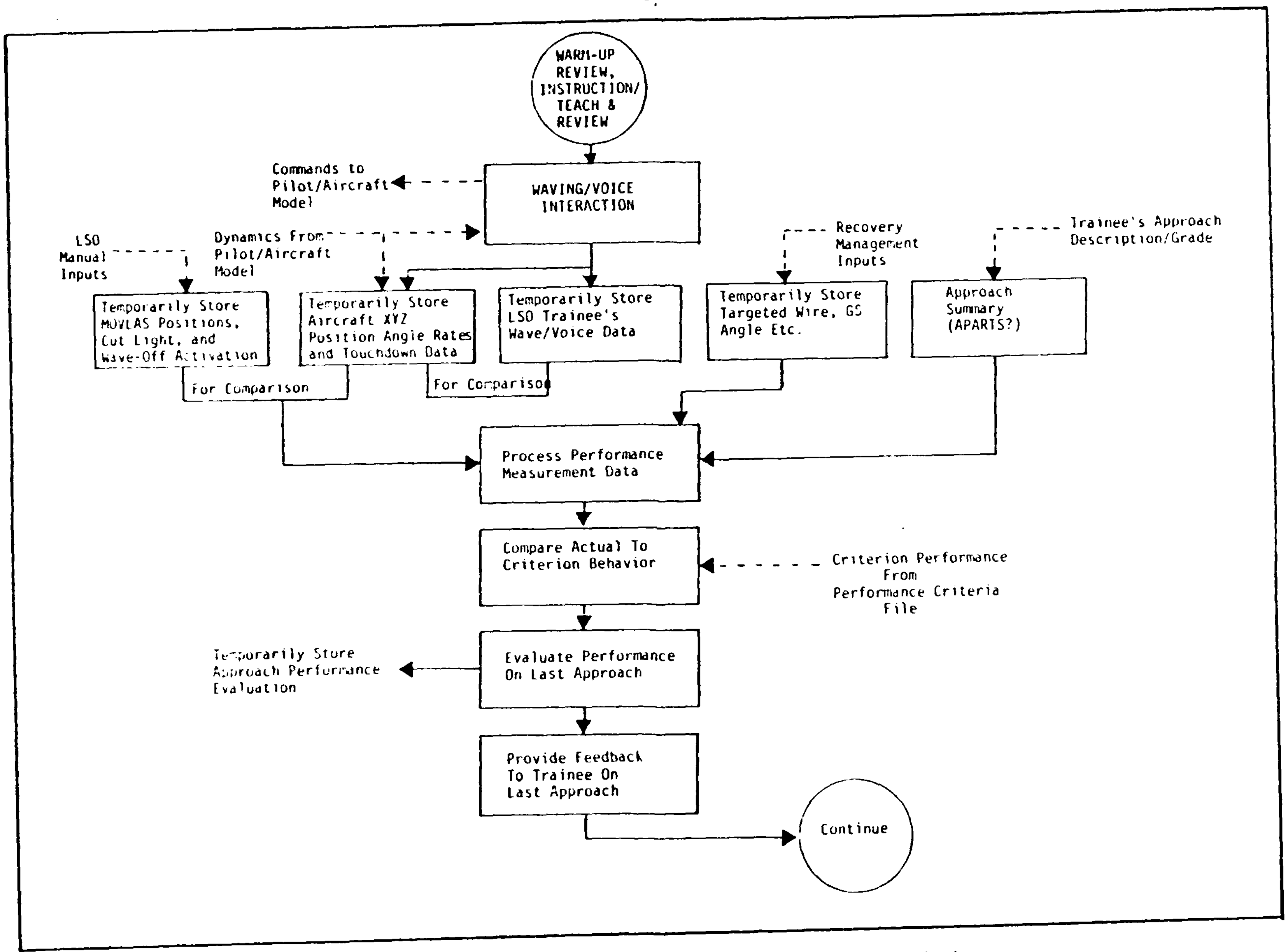

Figure A III-6. System Flow for the "Approach" Operation of the Performance Measurement and Evaluation Unit

A flow diagram for the PME long term operation is shown in Figure A-III-7. It functions in the background in the "Practice" sub-mode to evaluate the overall recovery performance and management of the recovery by the trainee. Information about each recovery performance evaluation will be temporarily stored for post recovery debriefing.

Evaluation and diagnosis of the trainee is short and long term performance is conducted as a foreground program on completion of the recovery and prior to the automatic selection of the debrief sub-mode. A flow diagram which represents this part of the performance measurement and evaluation unit is shown in Figure A-III-8.

Training Development Module (TDM)

The training development module will be used to optimize the curriculum for the LSOTS. This development module will be used by training and system analysts to:

1. Develop a model which represents the normal trainee's learning behavior with respect to any instructional unit in the curriculum.

2. Adapt the curriculum such that the trainee may proceed at his own pace by processing data collected about the progress of initial students exposed to the LSOTS.

3. Optimize the curriculum control by developing an allocation model of the trainee's cognitive resources.

4. Develop the waving performance evaluation processes.

The TDM will use a trainee knowledge data base to store and provide information about the model trainee and about utilization of the curriculum by individual and groups of trainees. Therefore, the TDM will be divided into five sub-programs as follows:

Trainee model

Curriculum adaptation

Cognitive resource allocation assessment

Optimization processes

Performance evaluation processes

The output of these sub-programs will be inactive until the optimized curriculum control software version #3 is released for use.

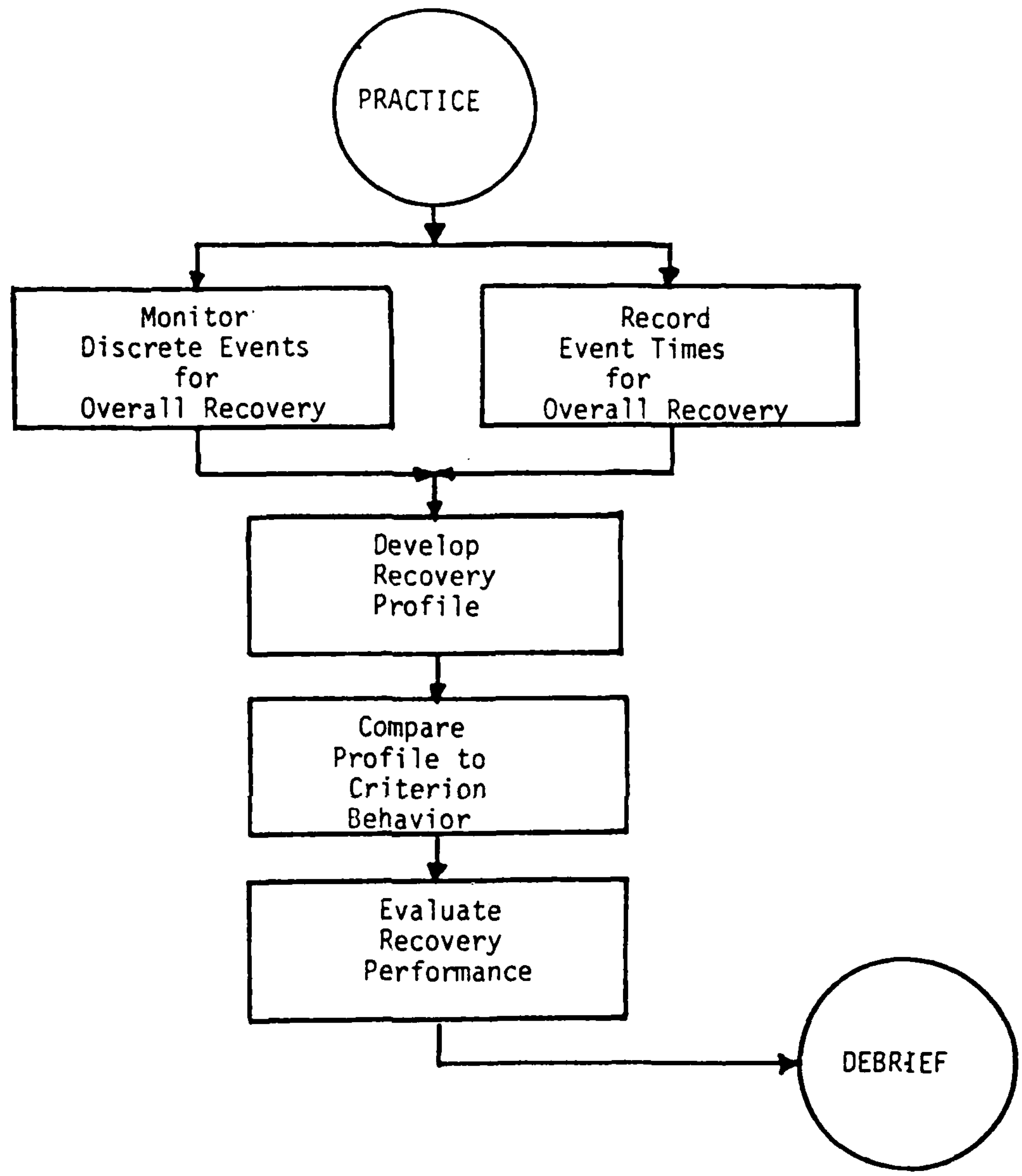

Figure A III-7. System Flow for the Recovery Operation of the Performance Measurement and Evaluation Unit

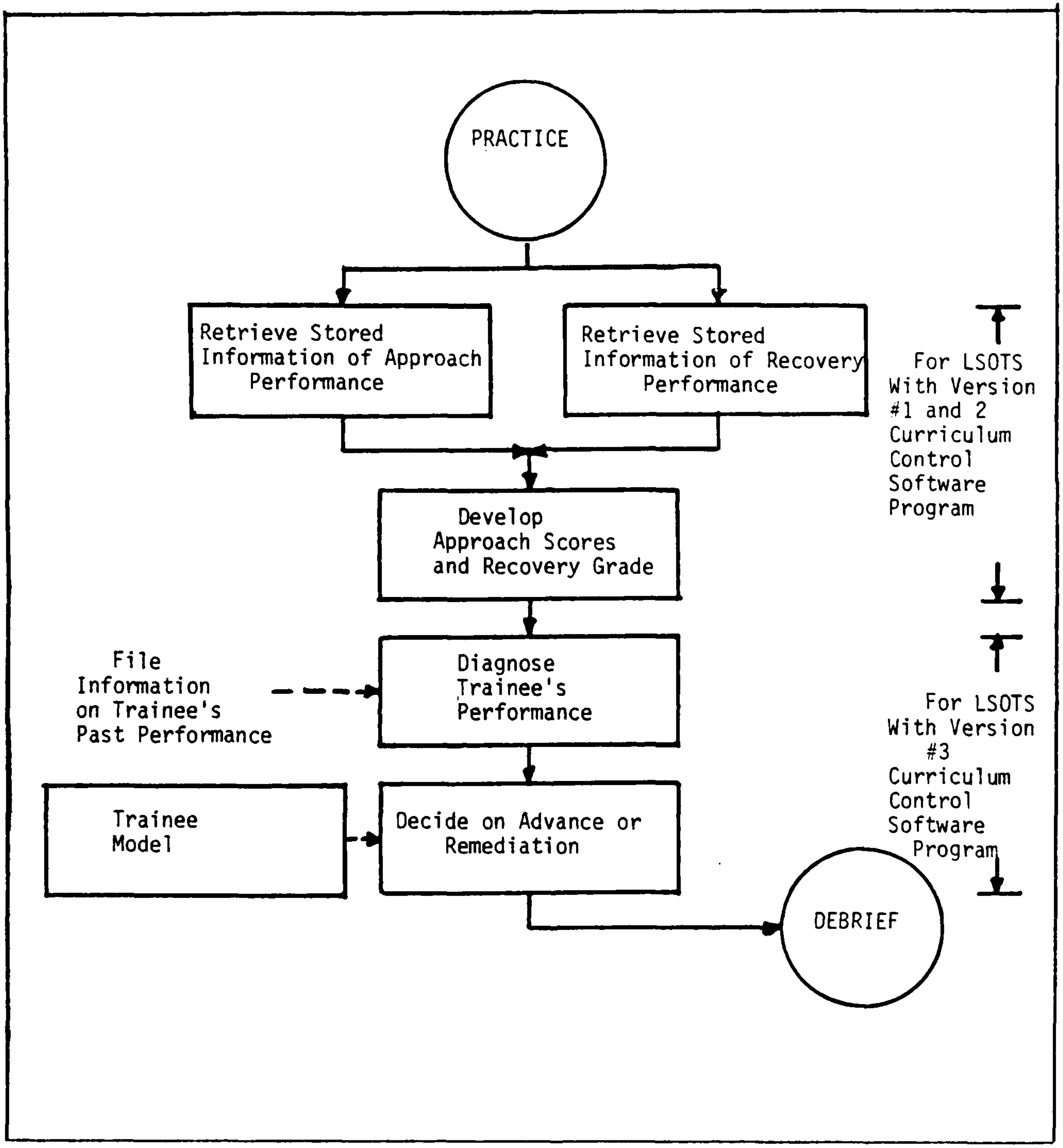

Figure A III-8. System Flow for Evaluation and Diagnosis of the Performance Measurement and Evaluation Unit

The trainee model will provide inferences about a trainee's learning status to enable: 1) the appropriate scenario to be selected by the curriculum controller; and 2) to generate actual trainee status reports for the human instructor.

The trainee model will receive inputs from the PME as estimates of the trainee's current level of proficiency. The trainee model will transform these estimates into a representation of the trainee knowledge and skill of the LSO task. This information also will be recorded cumulatively to represent the trainee's progress through the curriculum.

Curriculum adaptation development will be provided to enable individualization of a trainee's progress through the curriculum. Initially the development requires information as to how a group or groups of trainees perform the instructional units of the linear curriculum. This will enable a multiple path curriculum to be developed in which the primary control for self pacing is the trainee's performance on the previous task(s). This performance will be used to select the next task to be trained and its difficulty level.

The adaptive curriculum structure also will provide the opportunity for the trainee to challenge the LSOTS in specified key concept areas. If he passes the test for understanding the key concept he will be advanced to the next step in the curriculum.

The design principles for a cognitive resource allocation model are addressed in Section I of this Appendix. The use of a secondary LSO related task is suggested as a means of assessing the degree of cognitive capacity the trainee is allocating to the performance of the primary task. The outcome may provide more information about the trainee's learning status as an indicator to selecting the next task to be trained.

Optimization of the curriculum control operation will require the system to collect data about the progress of many trainees through the curriculum (see Chatfield and Gidcumb,1977). An heuristic process is required in which hypotheses about alternative CC strategies are tested by the accumulated data, and, thereby, the CC process is optimized over time. This represents a very advanced application of artificial intelligence (AI) principles to adopting the course content to the progress and inferred cognitive development of each trainee. This should be considered a high risk development, suitable for later stages of LSOTS implementation. However, the capacity to record the details of the progress of each trainee on the LSOTS must be allocated from the outset to support the eventual optimization process.

The waving performance evaluation process development is directed at discriminating between LSO trainee perception problems (like "High Eye") and aircraft controlling logic problems. Inputs to the developmental process will be the actual LSO waving commands and the approach descriptors i.e., aircraft control logic and the perceived approach profile respectively.

Trainee Interface (TI)

This interface between the trainee and LSOTS represents the visual and audio environment normally experienced at the "control" LSO's position on the LSO platform of a carrier flight deck. Additionally, controls and displays must be available to enable the trainee to operate the LSOTS. The TI includes the following elements:

1. The visual and audio simulation of individual aircraft (and a series of aircraft) approaching the carrier, landing, or boltering.

2. Communications between the trainee and the pilot of the approaching aircraft.

3. Communications between the trainee and other aircraft in the approach pattern.

4. Communication between the trainee, the air boss, CATCC and other appropriate operational personnel.

5. Communications between the trainee and the backup LSO standing to his right. (In the LSOTS this most likely will be the instructor).

6. Communications between the trainee and the instructor at his console.

7. Simulation of ship-related equipment normally found at the LSO platform.

Visual simulation of the landing scene will be presented to the trainee in an enclosure which can be environmentally controlled for day/night conditions. When the trainee and the back-up LSO are standing side by side, they will both see the identical scene. The resolution and details of the simulated scene should attempt to improve on the specification for the LSO reverse display training system (Device 2F103; see Hooks and McCauley, 1980).

Communication between the trainee and the approaching aircraft pilot will be made using the standard LSO handset with press-to-talk key. Modification of the handset for the LSOTS to provide optimum microphonic noise cancellation is anticipated. The communication from the trainee will use computer speech recognition techniques in association with a standard vocabulary except in the manual back-up sub-mode, at which time direct communication will be made to the instructor's console. Input communications for all modes are summarized in Table A-III-4.

The communications from simulated aircraft pilots to the trainee will be computer generated using a standard vocabulary. The character of the computer generated voice will be different for each aircraft pilot.

TABLE A III-4. UTILIZATION OF INPUT COMMUNICATIONS

All Normal Modes

To ↓ / From →	LSO Trainee Handset	LSO Backup Handset	Instructor's Console Handset
Waving Calls to LSOTS	Yes	Yes	No
Approach Description to LSOTS	Yes	Yes	No
Functional Commands to LSOTS	Yes	Yes	Yes
Backup Mode with Instructor Present			
Waving Call to Instructor	Yes	Yes	No
Approach Description to Instructor	Yes	Yes	No
Aircraft and Other Related Communications to LSO Trainee	No	No	Yes

*Note

If Instructor is not present, the LSO Trainee will communicate with LSOTS through the small keyboard at the back of the LSO Control Station.

Consideration should be given to digitized speech to achieve realistic voice inflections and, consequently, high user acceptance. In the manual-back-up mode the instructor will simulate the pilot's communication to the LSO trainee.

Communications from the trainee to the air boss or other operational personnel will be simulated by using the controlling LSO's handset, and an appropriate callsign. Communication to the trainee from the air boss, CATCC, hook spotter, phone talker, air ops, aircraft handler, arresting gear officer and other appropriate operational personnel will be computer generated using a standard vocabulary. The character of the computer generated voice communications to the trainee will be different for each person.

Equipment at the LSO platform will be used in the LSOTS whenever possible. This will promote a realistic simulation, and incresed user acceptance, if not adding to training effectiveness. The equipment will include an LSO Heads-Up Display (HUD) and CLASS capability, so that the LSOTS can effectively support training for ships with and without these new technologies. A PLAT will be included, although its use may be confined to team-training for the Back-Up LSO.

Human Instructor Interface (HII)

The human instructor may operate from either his main console or from the back-up LSO position.

The system interface at the back-up LSO position must be capable of supporting the operation of either a trainee or an instructor. The visual and equipment interface at the back-up LSO position will be the same as at the controlling LSO position, since they will be standing side by side, as on the LSO platform. The major interface consideration for the back-up LSO will be that the visual system is capable of presenting the primary display scene without distortion. Additionally, a PLAT will be available for use by the back-up LSO in giving supplementary line-up information.

The system interface at the instructor's console will provide two visual displays and two methods of system control. The two visual displays will be a direct view of the primary display (trainee's visual scene) and a CRT at the instructor's console. The optimum design is to enable the instructor to see the primary display while seated at his console. To achieve this objective, his console may have to be elevated so that his seated line of sight is slightly higher than the eye-height of the average LSO trainee. If the optical arrangement proves too difficult or costly to service three simultaneous observers (controlling LSO, back-up LSO, and instructor), then the instructor must be given a repeater display of the primary visual scene. If such a repeater display is provided, the instructor should have the option of reversing the scene to view the approach from the pilot's perspective. The instructor's console CRT will display information about system status, trainee records, speech recognition output and other functions selectable by the instructor. Hard copy output of this information will be selectable, but the printer will be external to the simulation enclosure to reduce noise.

The two methods of system control available to the instructor will be voice and keyboard. Voice control of LSOTS functions will be provided when the instructor is in the back-up LSO position. Keyboard, pushbutton and other appropriate controls will be provided at the instructor's console. The instructor will be able to accomplish only a subset of his console functions when using voice control at the back-up position.

The training supervisory interface which is provided through the instructor's console will include:

1. CRT display of the LSOTS visual scene as seen by the trainee.

2. CRT display of alphanumeric information commensurate with the LSOTS operating mode and data entry/output status of the LSOTS.

3. Keyboard entry of data through the alphanumeric keyboard.

4. Entry of commands to the LSOTS from special function keys which do not reside on the keyboard ("freeze" for example).

5. Intercommunciations with the trainee and external console.

6. Repeated communications between the LSOTS and the trainee.

7. Incremental control of the approaching aircraft with respect to the glide path in the manual back-up mode.

Audio communications will be provided through an intercom unit with person(s) at the external console and at the trainee's position in the manual back-up sub-mode. Communications between the trainee, approaching airfcraft, the air boss, CATCC and other landing operations personnel will be repeated at the instructor's console.

Appropriate controls will be provided at the instructor's console to incrementally control the approach of the simulated aircraft in the manual back-up mode. The will provide the capability to incrementally update departures from the approach profile determined by the pilot/aircraft model simulation control.

Although the external console is primarily intended as the offline interface with the LSOTS, it will be very similar in system design to the instructor's console with the following exceptions:

- o No special function keys will be provided
- o No approach aircraft incremental control will be provided.

Speech Recognition Subsystem (SRS)

The SRS will recognize utterances from the trainee in a foreground program within one second for the following circumstances:

- o Waving commands or calls given to the pilot of the approaching aircraft.
- o Approach description (normally given to the "book-writer" LSO immediately after each landing).
- o Recovery management communications given to the air boss, CATCC and others.
- o Functional commands which control the operation of the LSOTS.
- o In response to LSOTS requests (made thru the LSOTS speech generation subsystem) for voice data collection of the trainee's and/or instructor's speech characteristics.

The SRS will recognize utterances from the back-up LSO for aircraft control and for functional commands which control the modal operation of the LSOTS.

Vocabulary Partitioning and Control. Each SRS operation will be controlled by the press-to-talk key on the handset of the controlling LSO or back-up LSO. Each SRS operation will use a dedicated vocabulary as shown in Tables A-III-5 thru A-III-7. The recognition of these vocabularies by the SRS will be partitioned through the use of mutually exclusive circumstances as follows:

Waving Vocabulary - Start: handset keyed and aircraft approaching at $\leq$ 1 1/2 N.M. range Stop: handset not keyed and approach ended (wave off, arrestment, bolter, or crash) in last 15 seconds.

Approach Description - Start: handset keyed and aircraft has completed approach in last 15 seconds and verbal command of approach description is given by the LSO trainee. Stop: handset not keyed or approach description ended plus 15 seconds.

TABLE A III-5. LSO WAVING CALLS VOCABULARY

Imperative Calls	Informative Calls	Precautionary Calls	Non-Standard Calls
"A little power"	"You're (a little) high/low	"Check your lineup"	"Hold it up"
"Power"	"You're going high/low	"Don't settle" or "Don't go low"	"Fly the ball"
"Go Manual"	"You're lined up left/right"	"Don't climb" or "Don't go high"	"Fly it on down"
"Attitude" - ("A little)	"you're drifting left/right"	"Keep your nose up" or Hold your Attitude"	"The deck is moving
"Right/Left for lineup"	"You're fast/slow"	"Hold what you've got"	"Catch it"
"Bolter"	"Roger Ball"		"Stop it in the middle
"Waveoff" or "Waveoff, Foul deck"	"Paddles Contact"		"Don't go through it"
			"Nice and easy with the power"
"Cut"			
"Speedbrakes"			"You're Settling"
"Extend Speed-Brakes"			"You're underpowered"
"Drop you hook"			"The deck's down - hold what you've got"
"Drop your gear"			"The deck's steady - good ball"
"Drop your flaps"			"You're working a little low"
"Uncouple"			"Ease it down"
			"Start it down"
			"Work it off nice and easy"
			"Start it back to the right/left"
			"Don't decel"
			"Fly it down"
			"Don't chase the ball"
			"Get it back up"
			"Work it up"
			"Center the ball"
			"Put it on glideslope"
			"A little left/right for lineup"

Note:

*Refer to LSO NATOPS and Hooks, et. al (1978) for explanations.

**No non-standard calls should be included in the LSOTS without the express permission of the LSO Training Model Manager.

TABLE A III-6. LSO APPROACH DESCRIPTION VOCABULARY

General Descriptors

Waveoff
Own waveoff
Test waveoff
O.K. Underline
O.K.
Fair
No Grade
Cut
Bolter
A little (or slightly)
In a box
In a circle
Over-controlled
APC or AUTO
Manual
Pitching deck
Mode 1

Descriptor Suffixes

In the turn
Out of turn
At the start
In the middle
In close
At the ramp
To land
In the wires
All the way

Specific Descriptors

Angling approach
Accelerate
All Fouled Up
Flat glideslope
Climbing
Coming back to the left
Coming down
Come-on
Climbed on come-on
Chased
Chased Pitching Deck
Cocked up
Decelerate
Dived for deck
Dropped left wing
Dropped nose
Dropped right wing
Eased gun
Fast
Fouled Deck
Gliding approach
High
Long in the groove
Late line up
Landed left
Left to right
Landed right
Lined up left
Lined up right
Not set up
Nose down

Specific Descriptors

Not enough attitude
Not enough left rudder
Not enough power
Not enough right rudder
Not enough straight away
No hook
Not lined up
Overshoot
Over the top
Overshot coming back
Power
Pulled nose up
Rotate
Rough
Right to left
Settle
Ship in turn
Slow
Spotted Deck
Steep turn
Too close abeam
Too much rate of descent
Turned too late
Turned too much
Turned too soon
Too wide abeam
Underline
Landed 3 points
Landed nose first
Landed left wing down
Landed right wing down

TABLE A III-7. CANDIDATE LSOTS FUNCTIONAL COMMAND VOCABULARY

Continue	Display
Terminate	Power
Continue Copy	Angle of Attack
Terminate Copy	Attitude
Demonstrate	Glide Slope
Instruct	Sink Rate
Manual	Line Up
Repeat	
Voice Test	
Approach Description	
Replay	
Freeze	
Cross-Hairs	

Note

These commands can also be entered through the Instructor's Console Keyboard

Functional Commands of LSOTS - Start: handset keyed and an aircraft is not on approach at (limited to the warm-up/review instruction/teach or practice sub-modes). Stop: headset not keyed or an aircraft is approaching at $\leq$ 1 1/2 N.M. range (limited to the warm-up/review instruction/teach and practice sub-modes).

Note that the vocabularies for LSO calls and for approach description are subject to annual change by the LSO community. Therefore, the vocabulary structures must be designed to accept these changes.

Voice Data Collection. Voice data collection will be accomplished through the SRS in the instruction/teach and voice data test sub-modes. Visual information is preferred over the speech generating subsystem for prompting the trainee and/or instructor to say specific vocabulary words and/or phrases. The speech samples should be collected in the context of the use of the phrase. The voice data collection software program will provide a 256 word/phrase vocabulary. It will be possible for each word/phrase to be said with different voice inflection stored in the speech recognition data base with different labels. Normally, prompting for the vocabulary word/phrase will be imbedded as part of each instructional unit that requires an expansion of the basic vocabularies. Note that the basic vocabularies will be prompted and trained as part of Instructional Unit #1.

Voice Data Test. The voice data test sub-mode can be selected automatically by the LSOTS, verbally by the trainee, or manually through the instructor's console keyboard. The words/phrases to be reacquired will be selected similarly, either automatically via the confusion matrix program, or by the instructor or the trainee.

Automatic selection of this voice data reacquisition sequence is triggered by a numerical index of the discrimination between the word(s) phrase(s)/phrase(s) previously acquired. Confusion manifests in two ways: 1) the word/phrase is confused with a word/phrase of a similar acoustical structure, or 2) the word/phrase acoustical pattern is dissimilar to any acoustical pattern previously acquired.

As discussed under the voice data test sub-mode in Section A-II of this Appendix, the instructor and/or trainee will be able to visually review the matrix status before and after voice data collection.

Speech Generating Subsystem(SGS)

The SGS will generate utterances from the LSOTS to the trainee and/or the instructor within 1 second for the following conditions:

- Communication from the approaching aircraft or aircraft about to begin approach.
- Communication from (or inter communication between) the air boss, CATCC and other operational personnel.
- Instructional commentary made to the trainee by the LSOTS.
- Interrogative questions to the trainee and/or the instructor by the LSOTS to control the progress of the training session.
- Prompted words and phrases used in voice data collection.

Each communication will sound natural and be characteristically different for each entity used in the LSOTS. Each communication will be drawn from a vocabulary of expressions which are representative of tasks performed by that entity. It should be noted that the different characterization of voices heard by the trainee will be essential for thier proper identificaiton. A reasonable repetoire of LSOTS system entities is as follows:

LSOTS Simulated Instructor

Air Boss

CATCC

Approaching Aircraft (5 total)

Hook Spotter/Phone Talker

<u>Training System Executive (TSE)</u>

The description which follows embraces the pilot/aircraft model which is managed by a common TSE, the system design for which is part of the instructor model development and is depicted in Figure A-III-9.

The TSE will perform four primary operations as follows:

(1) Manage the data flow between the major software program modules of the LSOTS.

(2) Control the moding and sub-moding of the LSOTS.

(3) Monitor the reactions of the LSOTS unique software programs the operations provided by the host computer and it's peripherals.

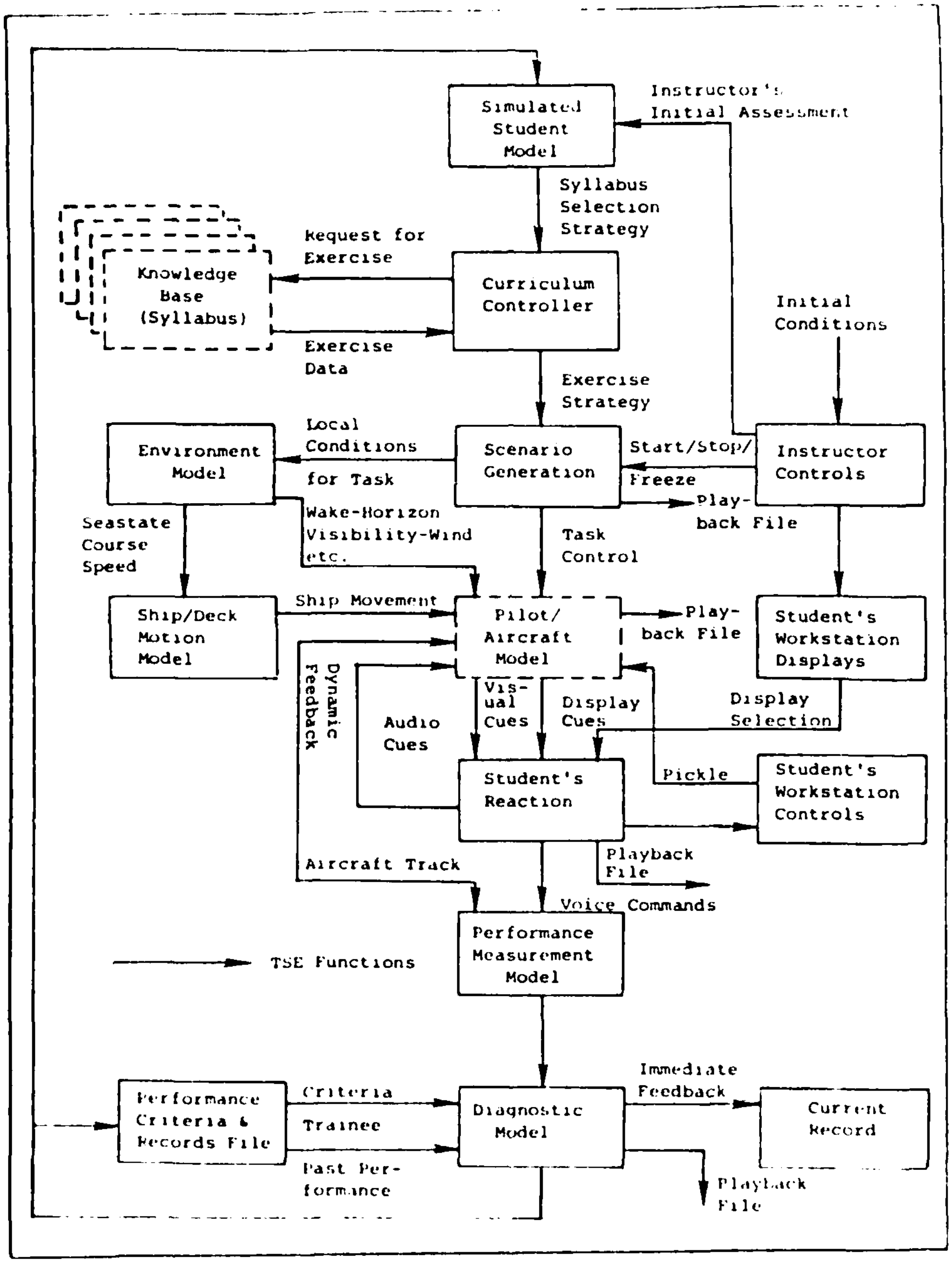

Figure A-III-9. Training System Executive For A Candidate LSOTS

(4) control the flow of commands and data between the unique LSOTS software programs and the host computer operating program.

Because of these requirements, the TSE will operate as a foreground program using interrupts to accommodate time sensitive events.

Tables A-III-8 to A-III-14 describe the general flow of data between the LSOTS software program modules. Real time interrupt requirements are noted when known. The data flow information is predicated on the functional design described in Section II of this Appendix and is not intended to be used for detail at this point in the LSOTS design. Acronyms used in the Tables are described in the acronym listing following the body of this report.

A3.3 LONG TERM DATA FILES

The expression "long term" is used to identify those files which contain permanent information about the trainee and/or his training. Inspection of these files can only be made in the "Access Record" sub-mode or be altered by qualified persons in the "Off-Line" mode.

Curriculum (CUR)

The curriculum file will be divided into three sub-files as follows:

Structure - Contains information on how the instructional units are linked together to form the curriculum. Initially the linkage will be serial (see Appendix C). However, later versions will link instructional units together in networks with alternative pathways.

Instructional Unit - Contains all the information to be presented to the trainee during a specific training session. It also contains the scenario codes for use by the pilot/aircraft model in order to provide the necessary simulation. In addition, the instructional unit will contain information and recommendations which will assist a human instructor in conducting the session, if he chooses to be present.

Strategy - Contains information on the instructional strategy which is designed into the curriculum structure and content of each instructional unit.

Trainee Records (TR)

The trainee records file will be divided into three sub-files as follows:

TABLE A III-8. CURRICULUM CONTROL INPUT/OUTPUTS MANAGED BY THE TSE

	INPUTS	FROM	INTERRUPT
1.	Voice control commands of LSOTS	-	*
2.	Voice control commands of LSOTS	TI	
3.	Keyboard control commands & requests	HII	
4.	Keyboard control commands & requests	TI	
5.	Routine system status messages	TSE Monitor	
6.	Curriculum structure	CUR	
7.	Selected instructional unit content	CUR	
8.	Trainee's position in curriculum	TR	
9.	Trainee's immediate past performance on LSOTS	TR	
	OUTPUTS	TO	
1.	Scenario generation codes	SG	
2.	Information/recommendations for human instructor	HII	
3.	Speech generation request and content	SGS	
4.	Request for visual feedback & effects for trainee	SG	
5.	Request for replay	TSE Mode Control	
6.	Request for freeze	TSE Mode Control	Yes
7.	Request for voice data acquistion	SRS	
8.	Routine curriculum control status messages	TSE Monitor	
9.	Trainee's revised position in curriculum after training session	TR	

* Note: An interrupt is not required unless stated.

TABLE A III-9. PERFORMANCE MEASUREMENT AND EVALUATION UNIT INPUT/OUTPUT MANAGED BY TSE

	INPUTS	FROM	INTERRUPT
1.	Recognized (and understood) words/phrases by trainee and/or instructor	SRS	
2.	Information about the aircraft	PAM	Yes
3.	Contextual information about the aircraft environment	SDC	
4.	Trainee action data (cut, wave-off MOVLAS	TI	
5.	Human instructor's evaluation of trainee	HII	
6.	Approach performance data for post approach processing	Scratch	
7.	Recovery performance data for post recovery processing	Scratch	
8.	Priority system status messages	TSE Monitor	Yes
9.	Performance criteria for individual approaches and recoveries.	PC	
10.	Routine system status messages		
	OUTPUTS	**TO**	
1.	Performance evaluation of trainee on last recovery	TR	
2.	Performance feedback to trainee on last approach and diagnosis	SGS SDC HII	
3.	Performance evaluation and diagnosis of trainee for session debrief	SGS SDC HII	
4.	Routine PME unit status messages	TSE Monitor	

TABLE A III-10. TRAINING R&D MODULE INPUT AND OUTPUTS MANAGED BY TSE

	INPUTS	FROM	INTERRUPT
1.	Curriculum structure	CUR	
2.	Instructional unit contents	CUR	
3.	Trainee's performance on each instruction unit	TR	
4.	Trainee's experience as an LSO	TR	
5.	Trainee's history of use of LSOTS	TR	
6.	Model trainee predicted position in curriculum	TKDB	
7.	Routine system status messages	TSE Monitor	
	OUTPUTS	**TO**	
1.	Updated knowledge about model trainee	TKDB	
2.	Optimized sequence of instruction for sepecified trainees	TKDB	
3.	Training R&D module status messages	TSE Monitor	

TABLE A III-11. TRAINEE INTERFACE INPUTS AND OUTPUTS MANAGED BY TSE

	INPUTS	FROM	INTERRUPT
1.	Generated speech from aircraft and operational personnel	SGS	
2.	Generated speech for instruction and debriefing	SGS	
3.	Generated speech for contol of session	SGS	
4.	Normal speech from instructor console	HII	
5.	Audio cues from approach aircraft (engine noise)	SDC	
6.	Visual information for instruction	SDC	
7.	Visual information for feedback between approaches	SDC	
8.	Routine system status messages	TSE Monitor	
9.	Audio communications from the human instructor in the manual backup mode	HII	
	OUTPUTS	TO	
1.	Speech utterance for waving, pass description, recovery management and LSOTS control	SRS	YES
2.	Trainee actions (cut, wave off MOVLAS)	PME	YES
3.	Trainee interface status messages	TSE Monitor	
4.	Audio communication to the human instructor in the manual backup mode	HII	

TABLE A III-12. HUMAN INSTRUCTOR'S INTERFACE INPUTS AND OUTPUTS MANAGED BY THE TSE

	INPUTS	FROM	INTERRUPT
1.	Information and recommendations about and for training the specific trainee	CUR PME	
2.	Audio Communications from the trainee in the manual bakup mode	TI	
3.	Routine system status messages	TSE Monitor	
	OUTPUTS	TO	
1.	Control commands and requests	CUR SRS	
2.	Performance evaluation data for the trainee	PME	
3.	Modifications of selected scenarios	SG	
4.	Audio communications from the trainee in the manual backup mode	TI	
5.	Incremental control of the approaching aircraft's movements	PAM	
6.	Special function controls (freeze)	TSE Control	
7.	Human instructor interface status message	TSE Monitor	

TABLE A III-13. SPEECH RECOGNITION SUBSYSTEM INPUT/OUTPUTS MANAGED BY THE TSE

	INPUTS	FROM	INTERRUPT
1.	Speech utterances from the trainee	TI	YES
2.	Contextual information about aircraft status, etc.	PAM	
3.	Voice acquisition commands	CUR HII PME TI	
4.	Speech recognition patterns for the signed-on trainee and/or instructor	SRD	
5.	Input vocabulary data for the current session	SRD	
6.	Routine system status messages	TSE Monitor	
	OUTPUTS	**TO**	
1.	Recognized (and understood) word/phrases	PME SDC	YES
2.	Word/phrase discrimination indices	TI HII PME	
3.	SRS status messsages	TSE Monitor	

TABLE A III-14. SPEECH GENERATION SUBSYSTEM INPUTS AND OUTPUTS MANAGED BY THE TSE

	INPUTS	FROM	INTERRUPT
1.	Request and commands for generated speech	CUR SDC SRS	
2.	Routine system status messages	TSE Monitor	
3.	Output vocabulary	SRS	
	OUTPUTS	**TO**	
1.	Utterances resulting from stored data in the vocabularies and curriculum	TI	
2.	Utterances resulting from audio data temporarily stored for each approach in a recovery	TI	
3.	SGS Status messages	TSE Monitor	

Personal Description - Contains personal details; rank, ss#, age, flying experience, general education, service education and training, etc.

LSO Description - Contains LSO professional details, training, experience, qualification level, etc.

LSOTS Performance - Contains details of his performance on each instructional unit including instructor's assessment.

Performance Criteria (PC)

The Performance Criteria file will be divided into two sub-files as follows:

Approach - Contains the criteria for the model LSO performance during any aircraft approach (based on updated versions of the McCauley/Borden (in press) LSO Waving Model).

Recovery - Contains the event sequence and timing criteria and management decision criteria for recoveries under varying aircraft type; sea state, day/night and aircraft malfunction conditions.

Speech Reference Data (SRD)

The Speech Reference Data file will be divided into five sub-files as follows:

Trainee N - Contains acoustical reference patterns for a specified trainee as prompted by prior and current instructional units. Provisions will be made for 64 trainees at any one time.

Vocabulary 0 - Contains the coding for the speech generation vocabulary. Provision for 1024 words will be made.

Vocabulary 1 - Contains the words and/or phrases used in the LSO waving command vocabulary. Provisions for 256 word/phrases will be made.

Vocabulary 2 - Contains the words and/or phrases used in the LSO approach description vocabulary. Provisions for 128 word/phrases will be made.

Vocabulary 3 - Contains the words used in the LSOTS functional command vocabulary. Provisions for 32 words will be made.

Trainee Knowledge Data Base (TKDB)

The Trainee Knowledge Data Base will be divided into four sub-files as follows:

Model - Contains information which represents the performance of the trainee model in each part of the curriculum and for each instructional unit. This information can be updated by the training development module at the end of each session.

Adaptation (Version #2 Software) - Contains curriculum structures which are designed for trainee self-pacing. These can be updated by the training development module at the end of each session.

Optimization (Version #3 Software) - Contains curriculum structures which are optimized around the continuing development of the trainee model and which take into account testing for cognitive resource allocation.

Performance Evaluation - Contains data which discriminate between LSO perception performance and aircraft control logic.

AD-A121177 AUTOMATED INSTRUCTOR MODELS FOR LSO TRAINING SYSTEMS 2/3
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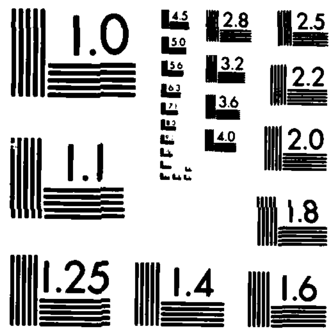


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

APPENDIX B

SOFTWARE MODEL DESIGN

SOFTWARE MODEL DESIGN

B1.0 INTRODUCTION

The intention of this appendix (as envisaged by NAVTRAEQUIPCEN) was to translate the various sub-models of the LSO Instructor Model into a system design for the systems analyst. Because the work contained in this report was conducted by training and systems analysts working together, the translation has, to a large extent, already taken place in Appendix A. Any redundancy between Appendices A and B was considered beneficial.

Furthermore, the contents of this software model design are very similar to the design, and presented in the companion report entitled "Pilot Behavior Models for LSO Training System" (Hooks and McMurry, in press).

B1.1 PURPOSE

This appendix describes the definition, design and development of the software for the Instructor Model portion of the Landing Signal Officer Training System (LSOTS).

B1.2 DESIGN

The LSO training program requires a medium which can provide instructional and interactive guidance in trainee task performance situations. This is currently being accomplished in the job environment of carrier landing operations under the guidance of supervisory LSOs. However, this dependency upon the OJT environment has become unacceptable due to frequent extended periods of reduced levels of operations and shortages of skilled LSOs. To supplement the OJT environment, an automated LSO training concept has been conceived and researched by the Navy.

The design concept of an automated LSO Training System is based on several required functional characteristics. It will provide visual simulation of the carrier landing environment from the perspective of LSO platform, and a means for LSO interaction with the pilot during the landing process. It will be independent of other training devices. It will provide automated support for instructional guidance, curriculum control, trainee evaluation in the learning process, and recording of trainee progress in the training program.

This design concept can be represented by five major system components as follows:

Trainee Station
Instructor Console
LSO Instructor Model (LSOIM)
Pilot/Aircraft Model (PAM)
Trainee Performance Records

These components and their interrelationships are depicted in Figure B-1.

The pilot/aircraft model requirements include approach profile control and dynamic response to LSO calls and signals during the approach. The purpose of approach profile control is to depict various deviations and trends in glideslope, lineup, and AOA for perceptual and decision skill acquisition. The purpose of dynamic response to the LSO is to present variations in pilot and aircraft responsiveness which must be learned. Requirements from the aircraft model include variations in aircraft type, aircraft malfunctions, and other approach characteristics (mode, configuration, and fuel state).

There are three technological areas which are important to the automated LSO training system, and consequently to the instructor model functions. Automatic curriculum control and its associated "intelligence" affects the quality of decisions made regarding pilot and aircraft behavior selections. The technological aspects of system design and their functional implications are addressed later in more detail. Automated speech recognition (and understanding) technology will be important to effect representation of pilot responses to LSO voice calls, and to enable automated performance measurement and evaluation. The effectiveness of pilot/aircraft model output is dependent upon the quality of visual simulation to portray the required dynamic cues.

B1.3 OPERATIONAL CONCEPT

The operational concept of an automated LSO training system is to provide instructional support for a variety of LSO training requirements, from basic through advanced skills. Basic skill areas include perception of aircraft approach dynamic cues, relating cues to appropriate LSO actions, and LSO workstation habit patterns. Intermediate skill areas include the formulation of aircraft control ("waving") strategies for a variety of aircraft types and pilot characteristics. Advanced skill areas include the extension of basic and intermediate skills into complex recovery situations, such as: aircraft malfunctions, difficult environmental conditions (deck motion, low visibility, non-optimum wind, etc.) and difficult operational conditions (low fuel state aircraft, arresting wires missing, mistrim of ship, malfunctions of workstation aids, etc.). In addition to aircraft control skills, the trainee must learn to make decisions associated with safety and efficiency of the overall recovery process. Throughout the training program the trainee will be learning increasingly complex concepts and relationships. The automated LSO Training System concept also encompasses refresher training for LSOs following extended absences from LSO duties.

The variations of behavior presented to the trainee are based on deliberate guidance from the instructional objectives. This guidance comes from an instructor (human or automated) component of the system. Pilot behavior will be represented in variations of the approach profiles being

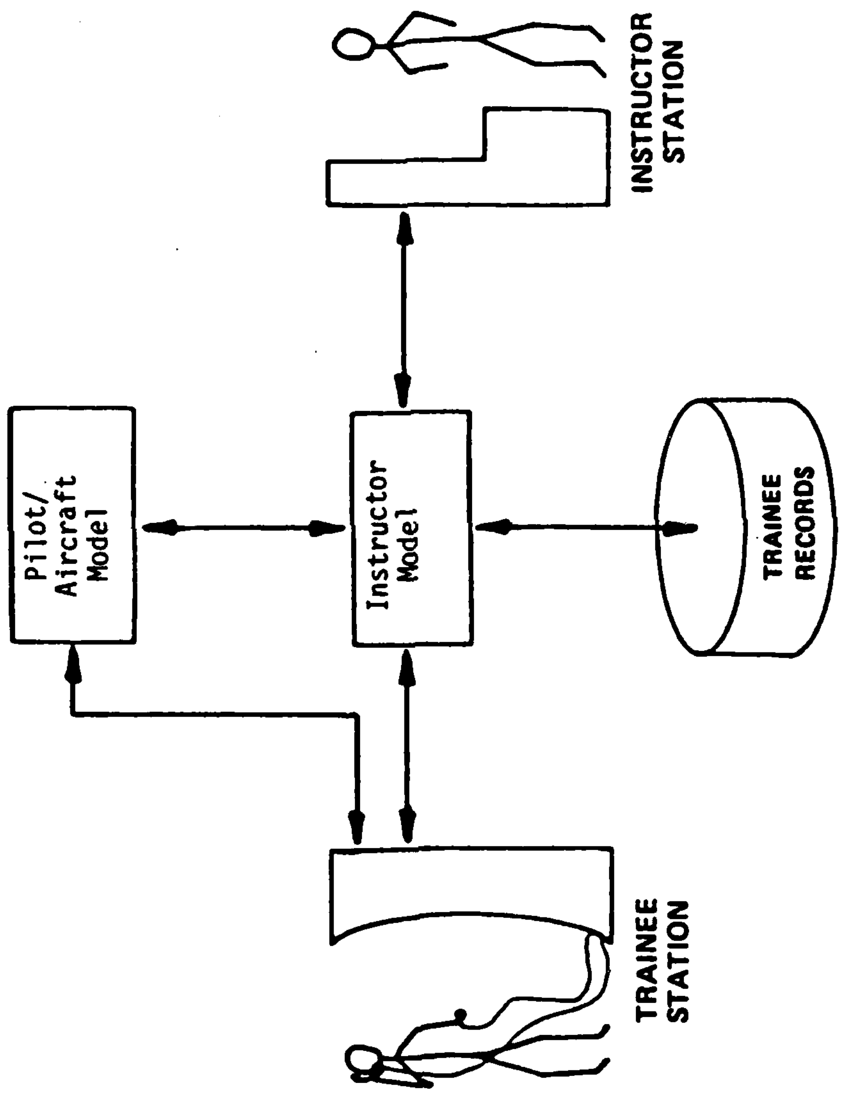


Figure B-1. LSO Training System Concept

observed by the LSO. It will also be represented in variations of how the pilot responds to calls and signals from the LSO. Aircraft behavior and appearance will vary by type of aircraft and aircraft system malfunctions.

B1.4 SOFTWARE

The LSOTS software is divided into applications and system software. The applications software is being designed based on the following objectives:

Top Down, Structured Design. The LSO Training System is being designed using a top-down, structured approach. This method involves defining the system in terms of functions provided at the highest possible logical level. The function interfaces are described while implementation details are assumed to be defined and available at the next lower level in a functional form. The process is repeated recursively at successively lower levels until all functional and procedural details have been identified. This occurs at the lowest level. In this way the exact details are left to be identified and solved only when the highest levels have been completed.

Modular Design. All LSOTS software is being designed around the concept of modularity. This involves partitioning the identified functions into separate software entities called modules. These modules are either internal procedures or external procedures. The use of external procedures in LSOTS software is being emphasized as this results in a system that is easier to design, implement, debug, and maintain.

System Connectivity. The concept of strongly versus weakly connected systems has long been a software design controversy. A strongly connected system is one that relies heavily on the use of shared memory variables to pass control information and data between modules. A weakly connected system uses parameters and variables that are "passed" between the modules that need to reference them. The LSO Training System is being designed as a weakly connected message driven system.

Data Driven. The LSO Training System software is being designed as a data driven system where all the input parameters, data and constants, and the majority of the control and decision logic are defined externally to the program in system resident disk files. This means that the execution and nature of the program depends solely on the data it uses. This approach allows one set of programs to serve many purposes each of which is defined by a new set of parameters and data contained in user selectable disk files.

Further details of the applications software are addressed in this appendix section B2.0 under the heading of "Program Design."

The system software will be influenced by the final hardware selection but it is assumed that it will be supplied either by the hardware manufacturer or a reputable software house. The design assumes that the system software will provide the following capabilities:

HOST COMPUTER EXECUTIVE. The Executive shall be capable of handling all low level device interactions as well as interpretation of console (CRT) user inputs. The Executive shall be capable of controlling multi-task programs.

LANGUAGE PROCESSORS. The system software shall provide at least one Higher Level Language (HLL) to be used for software development. While the exact language to be used will be greatly influenced by the final hardware selection, some of the advantages and disadvantages of several of today's currently popular HLL's are discussed below.

HLLs fall into two broad groups - unstructured and structured. However, all do share some common characteristics which make them desirable for use in the LSOTS software development effort. They all make use of symbolic variable naming constructs. They vary in the allowable length of variable names and legal characters. Most all of them have at least one implementation that supports separate compilation of program units (e.g., procedures, sub-routines, functions, etc.). All HLLs have floating point, integer, and logical data types. They all feature powerful numerical processing capabilities. Most support some system of statements to implement various control and sequencing capabilities and to perform logical tests of equality. Finally, most are available for a variety of hardware suites. The HLL selected for the LSOTS development must be standardized, supported on a wide selection of hardware, readily available, and widely known and used.

The structured language of PL/I (and its subset compilers) is an extremely powerful and versatile language developed several years ago by IBM. PL/I supports all the advantages listed above and some peculiar capabilities associated with defining the precision of numbers and implementation of bit fields. The latter capability is especially useful when memory is a limiting resource and execution time is not. PL/I also has a character data type which can be especially useful. The main disadvantage to using a member of the PL/I family is that its compilers tend to be somewhat memory inefficient in the code generated. Furthermore, almost all implementations are for either large IBM mainframes or small microprocessor based systems. For these reasons PL/I is not considered to be a serious contender.

PASCAL and its variants are extremely attractive as HLLs for software implementation because of the expanded nature of their statements for controlling program execution. This allows algorithms to be implemented in a very human oriented manner. Another important feature that PASCAL possesses is its variety of data types as well as the RECORD feature. This allows the designer/programmer to easily and quickly define new data types and data structures as the need arises and to specify clearly readable algorithms for their access.

PASCAL suffers from a lack of standardization. While many implementations share the spirit of the original language specification, vendors tend to add extensions that make the language somewhat less than portable. While this happens with nearly all languages developed by vendors, its effects are especially deterimental when there is no standard language specification upon which a majority of implementors can base their designs. Also related to this is the fact that PASCAL is still not a widely accepted language outside of the university community and while many hardware manufacturers offer a PASCAL, many still do not. These reasons all tend to reduce the desirability of using PASCAL for LSOTS software development.

ALGOL is a language that is a predecessor of PASCAL. Both languages share many common characteristics which may at first seem to make ALGOL the obvious choice. But, ALGOL also suffers from many of the same shortcomings as does PASCAL with two important additions. One, the language specification for ALGOL does <u>not</u> include any provision for input/output. This has resulted in as much as 90% of each program's execution time being spent either doing or waiting for input/output. Lack of an input/output specification is more than likely the primary reason that there are few ALGOL compilers available today and that those that are used are so different. Thus, ALGOL should be eliminated.

ADA fits in the category of structured languages and is viewed by many to be the ultimate solution to the software development problem. ADA incorporates most all the "good" features of the more popular HLLs available on the market today. It is also DoD's choice for software in embedded applications. ADA is not a serious choice because there are currently no commercially available compilers on the market. Furthermore, ADA is what could be termed too powerful for the LSOTS application since there are few of what are called exceptions in the LSOTS software architecture.

The next candidate HLL is 'C'. C was developed with a specific hardware architecture in mind and therefore takes advantage of that architecture in its capabilities and structures. C further has the advantage that it has all the power and flexibility of assembly language without the headaches. While many people still have not heard of C, those who have tend to become part of a group of dedicated users.

However, C suffers from the same two faults as do the previously mentioned languages - lack of standardization and limited implementation on a wide selection of hardware.

FORTRAN is probably the oldest and most widely accepted HLL currently in existence. It is also the closest thing to a truly standard and portable HLL available - mostly due to its long existence. Virtually every hardware manufacturer supports at least one standard version of FORTRAN. All usually have various extensions but over the years even the extensions have tended to become standardized. FORTRAN has the advantages of wide availability, support, and use. It is standardized and emminently portable.

FORTRAN does have two serious drawbacks. One is that its control statements have been criticized as awkward and lending themselves to unstructured programs full of "goto's." The other is that FORTRAN has almost no data structure capabilties other than arrays and matrices. Both of these have helped give FORTRAN a bad reputation for applications requiring manipulation of large data structures of varying data types.

These problems have been somewhat solved by the latest ANSI specification for FORTRAN 77. This specification extends the allowable control statements and adds new data types. If one of the various commercially available FORTRAN structured preprocessors is combined with a FORTRAN 77 implementation, the result should satisfy all the HLL requirements listed earlier. In addition, it would provide a software development environment that is both productive and as close to portable and hardware independent as is practicable.

Based on the above discussion, the HLL used for LSOTS software development should be a FORTRAN compiler (ANSI 77 or later if possible) used in conjunction with a commercially available structured FORTRAN preprocessor.

UTILITY PROCESSORS. The system software shall also provide an assortment of utility programs including editors, assemblers, standard device drivers, debugger(s), linking loader, object file librarian, and file manager. Also included shall be object libraries for peripheral use and system specific operations.

FILE SYSTEM. The operating system shall provide a means of storing information in the form of disk files. This file system shall be designed to support sequential, random, and indexed sequential file structures using either contiguous or linked disk allocation schemes. Files should be accessable for creation, deletion, updating, or extending from either a user console or under program control.

B2.0 PROGRAM DESIGN

The applications software program design is modular in concept, each module communicating with an executive program called the training system executive (TSE). The TSE controls the unique LSOIM and PAM functions and provides the interface with the host computer, operating program, and associated peripheral equipment.

B2.1 PROGRAM CONTROL

Unique LSOIM software modules which are controlled by the TSE are as follows:

Training development module
Curriculum control
Performance measurement and evaluation unit
Trainee's voice subsystem
Human Instructor's voice subsystem

LSOIM peripheral equipment interfaces which are controlled by the TSE and serviced through the host computer operating program are as follows:

Trainee knowledge data base - data file
Curriculum - data file
Trainee records - data file
Performance criteria - data file
Speech recognition reference data - data file
Trainee's interface - analog, discrete and audio data
Human instructor's interface - audio data only
Instructor's console - graphics and data terminal plus discrete inputs
External console - data terminal only

The TSE is responsible for routing all incoming and outgoing message traffic (data). From the LSOTS perspective, this responsibility includes the pilot/aircraft model where the TSE is referred to as the Simulation Executive. The individual modules and sub-functions are responsible for assuring that the data messages are properly formatted for pick-up by the TSE.

In addition to providing data flow control for the LSOTS, the training system executive fufills the following functions:

- Controls the moding and sub-moding of the LSOTS.
- Processes errors detected within the LSOIM and PAM and manages the exception handling.
- Manages the access to all LSOTS unique disk files and the use of selected routines in the host computer data management subsystem.

The TSE also controls and monitors the moding of the LSOTS (LSOIM and PAM). The primary modes are:

Initialize
Demonstration
Instructional
Manual backup
Off-line

The instructional mode is divided into several submodes which are illustrated in Figure A-II-1. The overall mode control is described in detail at the beginning of Appendix A section II.

B2.2 DATA STORAGE AND THEIR SERVICE ROUTINES

The host computer and/or it's peripherals will provide for the following LSOIM data files and their servicing. Inspection of these files can be made in the "access records" submode, or altered by qualified persons in the "off-line" mode.

Curriculum (CUR). The curriculum file will be divided into three sub-files as follows:

Structure - Contains information on how the instructional units are linked together to form the curriculum. Initially the linkage will be serial. However, later versions will link instructional units together in networks.

Instructional Unit - Contains all the information to be presented to the trainee during a specific training session. It also contains the scenario codes for use by the pilot/aircraft model in order to provide the necessary simulation. In addition, the instructional unit will contain information and recommendations which will assist a human instructor in conducting the session.

Strategy - Contains information on the instructional strategy which is designed into the curriculum structure and content of each instructional unit.

Trainee Records (TR). The trainee records file will be divided into three sub-files as follows:

Personal Description - Contains personal details; rank, ss#, age, flying experience, general education, service education, training, etc.

LSO Description - Contains LSO professional details, training, experience, qualification level, etc.

LSOTS Performance - Contains details of the trainee's performance on each instructional unit and will include instructor's assessments.

Performance Criteria (PC). The Performance Criteria file will be divided into two sub-files as follows:

Approach - Contains the criteria for the model LSO performance during any aircraft approach (based on updated versions of the McCauley/Borden LSO Waving Model).

Recovery - Contains the event sequence and timing criteria for recoveries under varying aircraft type; sea state, day/night, aircraft malfunction conditions.

Speech Data (SD). The Speech Data file will be divided into six sub-files as follows:

Trainee - Contains acoustical reference patterns for each trainee as prompted by prior and current instructional units. Provisions will be made for 64 trainees at any one time.

Vocabulary 0 - Contains the coding for the speech generation vocabulary. Provision for 1024 words will be made.

Vocabulary 1 - Contains the words and/or phrases used in the LSO waving command vocabulary. Provision for 128 word/phrases will be made.

Vocabulary 2 - Contains the words and/or phrases used in the LSO approach description vocabulary. Provisions for 128 word/phrases will be made.

Vocabulary 3 - Contains the words used in the LSOTS command vocabulary. Provisions for 16 words will be made.

Trainee Knowledge Data Base (TKDB). The Trainee Knowledge Data Base will be divided into three sub-files as follows:

Model - Contains information which represents the performance of the trainee model in each part of the curriculum and for each instructional unit (see Appendix C). This information can be updated by the training development module at the end of each session.

Adaptation (Version #2 Software) - Contains curriculum structures which are designed for trainee self-pacing. These can be updated by the training development module at the end of each session.

Optimization (Version #3 Software) - Contains curriculum structures which are optimized around the continuing development of the trainee model and which takes into account cognitive resource allocation testing.

B2.3 INSTRUCTOR/TRAINEE SUPPORT

The following software program modules are designed to provide the instructor/trainee with support in the overall context of the LSOTS.

Curriculum Control (CC). The curriculum control makes logical decisions to determine the next instructional unit to be presented to the trainee based on the following information:

- o Previous position of the trainee in the curriculum
- o Trainee's past performance on the LSOTS
- o Experience level of the trainee as an LSO
- o Trainee model's estimate of the trainee's learning status.

The primary purpose of the curriculum control is to provide automated logic for the selection of instructional units contained in the curriculum. The curriculum control takes performance information from the trainee's records and makes decisions about what information, instructon or practice problems should be presented to the trainee.

There will be three versions of curriculum control software as follows:

(1) Control of a linear (now-branching) curriculum developed by the training analyst.

(2) Control of curriculum which is a network of instructional units, designed to allow the trainee to proceed at his own pace (individualized instruction).

(3) Control of a curriculum which is a network of instructional units. The choice of instructional unit takes into account: a) when the trainee is ready to proceed further with the curriculum and/or; b) be exposed to other variables which will increase task difficulty.

The curriculum control will operate as a foreground program between the "select training" and "warm-up/review" submodes.

Performance Measurement and Evaluation Unit (PME). The PME will be used to measure, evaluate and diagnose trainee performance during each approach and for the overall recovery (multiple approaches).

For each approach, data will be gathered on the LSO waving call and the aircraft position and rates with respect to the approach path and landing. This information will be time logged and temporarily stored for processing between approaches and after each recovery. Performance evaluation after each approach or recovery will be based on a quantative model of the LSO waving calls and recovery management strategy. Actual and criterion behavior will be compared to arrive at approach and recovery scores.

Diagnosis of performance will be based on integrating errors over one or several recoveries and searching for trends in performance errors by the trainee. PME will run as a foreground program in the "warm-up/review," "instruction/teaching," and "practice submodes."

Trainee's Voice Subsystem and Human Instructor's Voice Subsystem. There is a great degree of commonality between these voice subsystems. For convenience of this description, it is divided into speech recognition subsystem (SRS) and speech generating subsystem (SGS).

SPEECH RECOGNITION SUBSYSTEM (SRS)

The SRS will recognize utterances from the trainee in accordance with prescribed stored vocabularies for the following circumstances:

- o Waving commands given to the pilot of the approach aircraft.
- o Approach descriptions given immediately after each landing.
- o Functional commands which control the modal operation of the LSOTS.
- o In response to LSOTS prompted speech request.

The SRS will also recognize utterances from the instructor (when standing in the backup LSO's position) for functional commands which control the modal operation of the LSOTs.

Voice acoustical pattern data collection for each trainee is required for each of the three command vocabularies for new trainees. This data collection is an integral part of the instruction contained in instructional unit #1. Additional data is collected during the "instruction/teach" submode as promted by the speech generating system. Provision will be made for selected word/phrases (such as "Power") to be said with different speech intonation by each speaker and stored in the speech recognition reference base with different labels.

Voice data test is automatically selected by the LSOTS or on request by the trainee or instructor. Automatic selection is triggered by a word/phrase discrimination matrix indicating that the word/phrase is confused with another word/phrase of similar acoustical structure or the word/phrase acoustical pattern is dissimilar to any acoustical pattern previously acquired. Voice data test will provide voice data collection for any word/phrase until the discrimination indices increase to a point which indicates confusion no longer exists.

The speech recognition process shall be run as a foreground program using the highest possible interruption of all other priority program functions. Processing delay in excess of one second is unacceptable.

Speech Generation Subsystem (SGS). The SGS will generate utterances presented to the trainee and/or the instructor for a variety of training related conditions. These are as follows:

- Communications from the approaching aircraft, or aircraft about to begin the approach.
- Communications from/or between the air boss and other operational personnel.
- Instructional commentary made to the trainee by the LSOTS during his progress through a training session.
- Interrogratives to the trainee and or instructor by the LSOTS to control the progress of the training session.
- Prompted words and phrases used in voice data collection of the trainee and/or the instructor's speech characteristics.

Each utterance will sound natural but characteristically different for each entity used in the LSOTS. Each word/phrase utterance will be drawn from a vocabulary of expressions which are representative of tasks performed by that entity.

Training Development Module (TDM). The TDM functions under the TSE to optimize curriculum control by providing a tool which will be used to: 1) develop a model of the normal LSO trainee's learning behavior; 2) adapt the curriculum so that the trainee can proceed at his own pace; 3) optimize the control of the curriculum by developing a model of the trainee's allocation of cognitive resources and; 4) develop performance evaluation strategy for recovery management.

The TDM will use the trainee knowledge data base to store and provide information about the model trainee and how the curriculum is used by individual and groups of trainees. The TDM will be used by training and system analysts to help them develop the curriculum control program for the instructional features enumerated above. The TDM may function as a background program during the "warm-up/review," "instruction/teach" and "practice" submodes.

B2.4 SYLLABUS (CURRICULUM)

Each instructional unit used in the curriculum will be predicated on information contained in the curriculum data files. The basic training information for the curriculum data files (CUR) is given in Appendix C of this report. The syllabus is intended to provide the development of perception, aircraft waving control, and recovery management skills for the trainee. A range of increasingly difficult exercises is structured into the data base and is divided into the following general areas:

Basic waving skills
Waving pilot and aircraft variations
Complex waving situations
Critical waving situations

The instructional unit which represents the relevant curriculum data file called out in compliance with the syllabus will also contain: 1) the instructional text to be given to support curriculum item; 2) the PAM scenario code which schedules the PAM to provide the appropriate visual simulation and; 3) any special vocabulary words which require voice data collection for effective operation of the SRS.

B3.0 CONSTRAINTS

This section describes the foreseen constraints which may limit the capabilities of an automated LSO Training System. Contraints are discussed under two major headings: training and system. Training constraints are categorized by general orientation, lack of clarity and/or definition of learning objectives and training tasks, hardware, software, and courseware. System constraints are those which deal with the actual implementation of the software or the hardware to provide the system.

B3.1 TRAINING

One of the potential constraints related to training capability is the performance quality of advanced technologies incorporated in the system. The visual simulation is one of these technologies. How well it can depict LSO task cues and other simulated conditions can have a significant impact on training effectiveness. However, at this time, it is not expected to be a technological problem area. Another potential constraint is the performance of automated speech recognition. Poor speech recognition and/or excessive processing for speech recognition results could have a negative impact on the effectiveness of trainee task interaction in training exercises. The advancement of the status of this technology is expected to be adequate to minimize concern in this area. The effectiveness of automated "intelligence" within the instructional control component of the system is another potential constraint. One of the goals of the system is to enhance LSO training effectiveness without imposing excessive burdens on the LSO instructor. This technology should provide assistance for "instructor-present" training sessions to enhance session efficiency and human instructor effectiveness. It should also enable some amount of "instructor-absent" training. There is little doubt that the technology can prove beneficial to LSO training effectiveness.

Even given adequate technology, there is still some uncertainty about how effectively some of the training functions will perform. Curriculum control, performance evaluation, and scenario presentation are important individual functions which can affect training effectiveness. Equally important are the functional interactions among these and other system functions, as well as the human interfaces provided for system operations. The system also must be designed for efficient modification in response to performance deficiencies and changes in LSO training requirements. Functional deficiencies in any of these areas can significantly constrain the training effectiveness of the system.

The most capable training system can fall short of desired training effectiveness through ineffective utilization. There are several potential constraints on utilization effectiveness. Quality control of the training plan and syllabus associated with the system is one area of concern. The training must be continually monitored, and revised as necessary to reflect current LSO training requirements. Adequate numbers of instructors must be available for the timely conduct of training. Adequate preparation of LSO instructors must be provided, including a comprehensive Instructor's Manual and a course of instruction on LSTOS management. If instructor and trainee attitudes toward the system are not considered in the system design, user acceptance will suffer. A "change advocate" for the system should be selected from the LSO community to assist in it's introduction into the LSO training program (see Mecherikoff and Mackie, 1970). Insufficient attention to these factors mentioned above can inhibit effective system utilization, and consequently its training effectiveness.

In summary, LSO training system effectiveness can be affected by many factors. The system design team must be aware of these technological, human, and training factors and their potentially negative impact throughout system design, development, and implementation phases. Significant involvement of user personnel will be required in design and development, as well as thorough testing of system functional and training effectiveness, and clear communication of system design objectives among the various personnel involved in the development of the system.

B3.2 SYSTEM

The primary objective of any complex software development effort is that the programs be developed in an orderly and efficient manner. A secondary benefit is that software developed be flexible and easily maintained. Too often the initial system analysis and requirements definition phases are poorly done or not done at all. This results in system designs that are not oriented to solving the problems at hand. This is one of the most obvious system constraints, yet it is very often overlooked or poorly understood. The following paragraphs serve to clarify procedures to follow to minimize potential development problems.

DOCUMENTATION. Much has been written about providing adequate documentation for software projects. The LSOTS should emphasize documentation in the areas indicated below.

Functional Design. The Functional Design is intended to be an important part of the LSO Training System evolution. It is a formal specification of the design of the entire system. It is organized in terms of the functions that the system must perform in order to fulfill the requirements imposed by the training objectives. It specifies the functions, their inputs, outputs, and the method of implementation. It is intended to serve as a guide to future design and implementation for those persons building the system. It is intended to represent the system design as of that state.

System Interface Document. The sole function of this document will be to record clearly and accurately the interfaces between all software modules and subsystems in the LSOTS. The format of the System Interface Document should be flexible as well as complete.

Program Design Practices. The Program Design practices used in developing software for the LSOTS should be centered around the use of what is commonly called "pseudo code." Pseudo code is simply the designer's (and programmer's) specification of the data structures, procedures, and algorithms used within a module to fulfill its defined function. Pseudo code has several distinct advantages over traditional methods such as flow charts and string charts. First, it allows the programmer to specify his solution to the problem in a way that is close to natural thought processes. This can dramatically speed up the design process alone. Second, the resulting pseudo code can be understood by non-programmers. This is important for the design review process when it can be valuable to have the opinions and constructive criticisms of others who may not be intimately familiar with all details of the design but who may have had similar design experiences. Third and perhaps most important, the resulting design can be readily comprehended by other project programmers and working code can be produced in the event of personnel changes. This can be of critical importance since many projects have problems with personnel changes.

While psuedo code can be produced manually using a text editor, it is strongly urged that a commercially available pseudo code processor be used.

Program Source Listings. The lowest and most detailed level of software documentation will be the program listings themselves. They will serve as the final reference for any changes or modifications to the softeware.

As a minimum, each program module listing should contain a header with the following information:

- o The module name if it does not already appear as part of the program.
- o The name of the principle author and the date the module was first created.
- o The name of each modifying author and the date of each major modification in chronological order as well as the nature of the change.
- o The module-calling sequence even if evident in the code.
- o A broad definition of the module's function. This includes inputs and outputs not obvious in the code, files referenced, external references, or any other information which is likely to be needed by another programmer to maintain or modify the program. If this module is the main module of a task then this section should contain a detailed explanation of how the entire task or program functions. This should include the circumstances under which it runs, how it communicates with other tasks or modules, as well as significant resources that it uses. It should be the program author's responsibility to see that this section contains all pertinent information.

GENERAL PROGRAMMING STANDARDS. The purpose of the standards and conventions described in this section is to ensure the writing of "proper" programs and thereby contribute to the ease of testing and integration of the software. Almost everyone in the software field has an intuitive feeling of what constitutes a proper program, but precise definitions are difficult. The following standards and conventions are presented as guidelines.

Modularity. Programs will be constructed of independent modules following the single function module concept. To the greatest extent possible, these modules will be designed so that they can be replaced or modified without affecting other modules.

Source Files. Each program module should exist as a separate file. This should also apply to "include" files if available on the system. Files should include documentation specifying all modules that incorporate them.

Comments. All comments should convey the larger functional role of a statement or instruction or a group of statements or instructions. A comment should not be the translation of the particular line of code into English. Any particularly obscure or complex section of code should be preceded by a paragraph of comments explaining the intention of that code. In any case there should be sufficient comments in a module to enable a following programmer to finish, test and debug, or modify the module.

Self Modifying Code. Self-modifying code should be permitted only in the optimization process called for in the training development module. Although there may be occasions where execution time and/or memory constraints or device requirements may make self modifying code seem attractive, it is certain that its use will make testing, debugging, and maintenance difficult if not impossible (even by the author).

Shared Temporary Storage. Modules should not share temporary storage among themselves. Sharing temporary storage requires the assurance that modules will not conflict with each other. This needlessly complicates system design, testing and debugging, and maintenance.

Local Data Items. Local data items should be defined in a separate section of the module preceding any executable code.

Entry Points. Each module should have only a single entry point. This entry point should be the first executable instruction or statement in the module.

Program Flow. Modules should be coded in such a way that they "flow" down the page, even at the cost of extra branches or jumps. This organization enhances the readability of the listings. This guideline is intended primarily for nonstructured assembly language programs.

Exit Points. All exits from a module (or submodule) should occur through a *single normal* or *one* alternate error exit point. These exit points should be the last executable statements or instructions in a module.

Module Length. Each module should be long enough to perform a single function. This should normally not require over 75 to 100 executable statements or one to two pages.

Variable Names. All variables should be explicitly typed and defined. At no time should any default data typing features be used. Variable names should be chosen to reflect or indicate the contents and/or use of the variable as much as possible within the limitations of the programming language being used. Where severe limitations exist for variable name lengths, variable use should be defined when the variable is defined.

Re-entrant Code. If available as part of the vendor software, all routines should be written to be re-entrant. This implies not using declarations which result in the allocation of "common," "own," or "equivalence" storage.

Debugging Measures. To the greatest extent possible, programs should be written to prevent or automatically detect errors (bugs). They should include measures to do the following:

- o Check the validity of arguments passed to a module.

- o Make range and other reasonableness checks on all data input from outside the program.
- o Check the range of control variables used in "CASE" statements or its analogue.
- o Make array subscript range checks, if not a compiler feature.

In some cases these checks may require extra code, and in some cases they may be accomplished by the use of compiler options. If the checks require additional code, this code should be clearly marked as such so that it can easily be removed after testing has determined that the program functions correctly.

APPENDIX C

LSO TRAINING REQUIREMENTS DATA BASE AND PRELIMINARY LSO SYLLABUS

C-I. LSO TRAINING REQUIREMENTS DATA BASE

The training requirements data base structure depicts an organizational scheme for what must be learned by the LSO trainee. Expansions within the major blocks (PERCEPTION, BASIC AIRCRAFT CONTROL etc.) depict sub-groupings of knowledge and skill components. This expansion leads to small learning components or to very specific key concepts to be acquired. The major blocks tentatively imply some sequencing from initial (PERCEPTION) to advanced (RECOVERY MANAGEMENT) skills. However, syllabus sequence will include some instructional maneuvering among the blocks.

The LSO training requirements are structured and identified using a logical progression of alphanumeric codes (such as 2.0, 2.1, 2.1.1, 2.1.1A). General training requirements statements are the basis for the structure and are identified with strictly numerical codes (such as 1.1.2 and 3.1.2.1). Diagrams are also included which graphically depict the structure. Key learning concepts are identified and correlated to the general statements with alphabetic modifiers (such as 1.1.2A and 3.1.2.1C). For each training requirement, relevant instructional variables (such as deck motion, approach profiles, pilot response) have been identified (denoted with "VAR:"). The codes for prerequisite training requirements are also identified (denoted with "REQ:"). Within the structure prerequisite requirements are also indicated by subordinate numerical relationships. For example, 3.1.1.1 is prerequisite to 3.1.1 which is prerequisite to 3.1. In essence, each major block is a hierarchy of unrefined learning objectives, similar to that which would be produced in an Instructional Systems Development (ISD) effort.

From this structure, a tentative linear syllabus will be derived. Influences on the syllabus sequence will include prerequisite training requirements, task difficulty, task criticality, task complexity and logical task relationships.

The training requirements, key learning concepts and training requirements structure are based on LSO SME inputs. However, they have not received explicit validation by the LSO Training Model Manager.

This is a preliminary training requirements (syllabus) data base and will eventually need further refinement and validation. Future efforts should include:

- revision of training requirements such that they are more behaviorally oriented.

- o increased specificity of related variables (i.e. when profiles are required they must be more specifically defined).
- o prerequisites and requirements for specific variables must be verified by LSO SMEs.
- o LSO SMEs must be alert for revisions needed and for adding other training requirements and key concepts.
- o knowledge prerequisites must be identified.
- o candidate performance measures and evaluation criteria should be identified for each training requirement (or group of training requirements.)

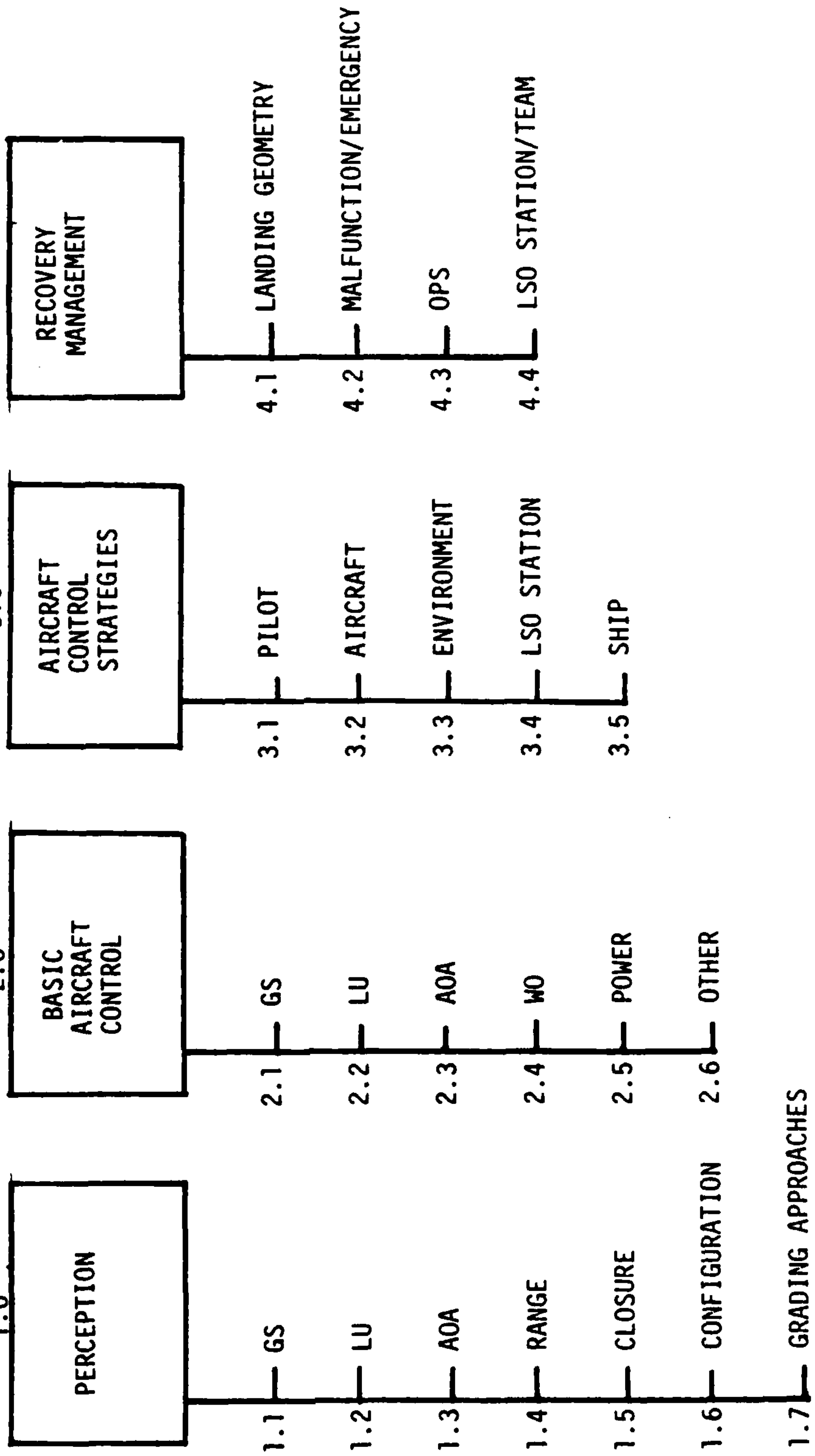
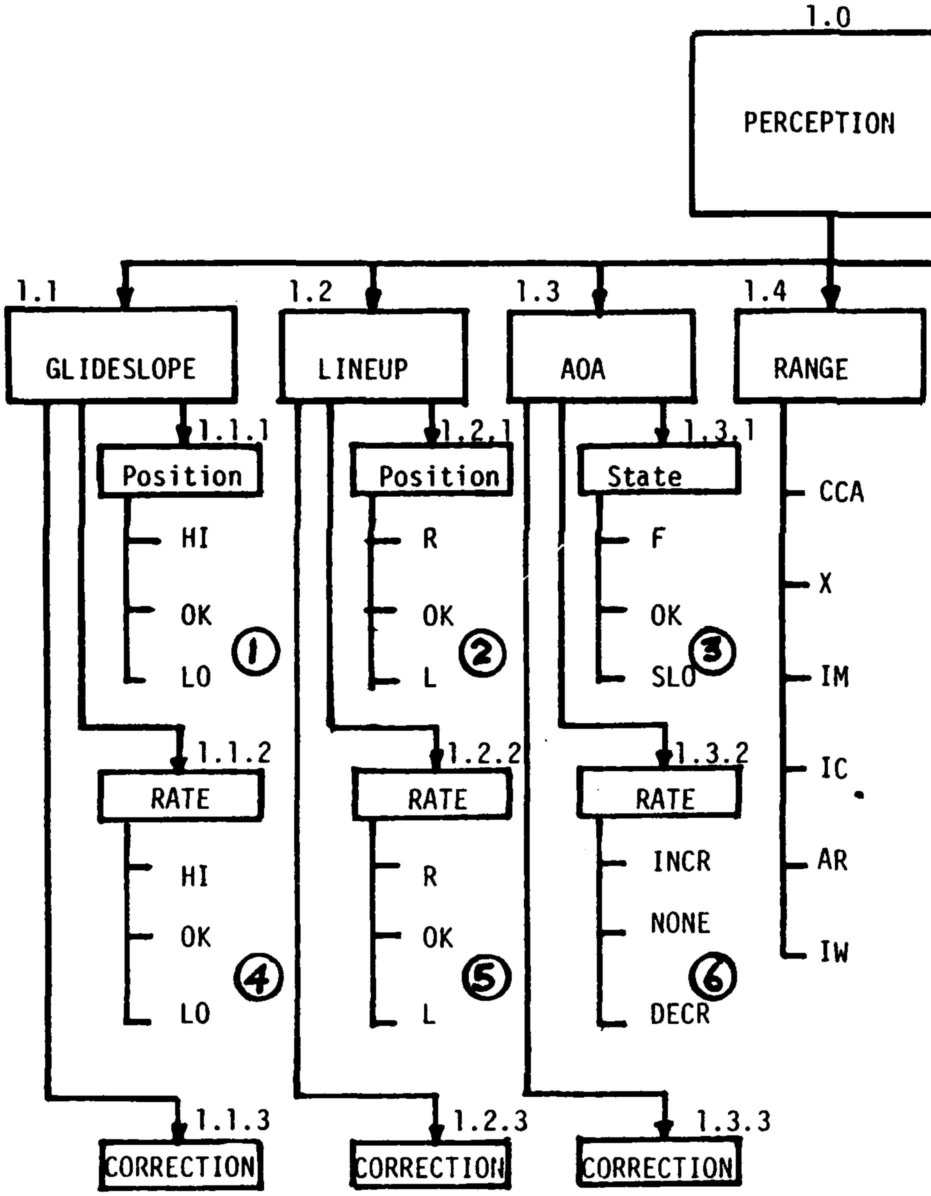


Figure C I-1. Training Requirements (Syllabus) Data Base Structure



<u>PERCEPTUAL CUES</u> (Circled Numbers)

1. Basic Angle.
2. Centerline Projection.
3. AOA Light, Attitude.
4. Pitch, Power.
5. Roll/Angle of Bank, Yaw, Heading.

6. Pitch, Power, Angle of Bank/ Lineup.

Figure C I-2.

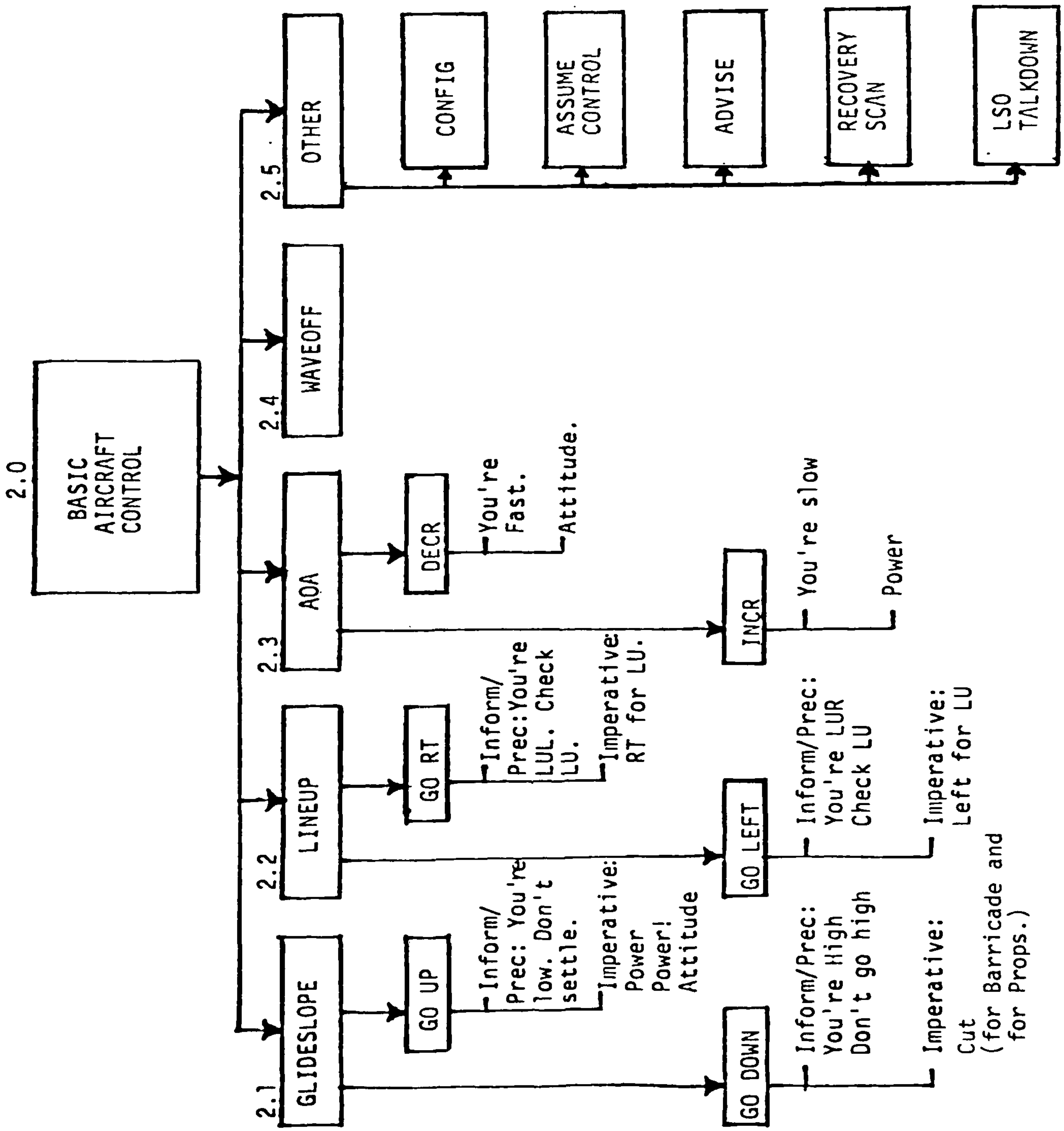

2.0
BASIC AIRCRAFT CONTROL
2.1
GLIDESLOPE
2.2
LINEUP
2.3
AOA
2.4
WAVEOFF
2.5
OTHER
GO UP
Inform/ Prec: You're low. Don't settle.
Imperative: Power Power! Attitude
GO DOWN
Inform/Prec: You're High Don't go high
Imperative: Cut (for Barricade and for Props.)
GO RT
Inform/ Prec: You're LUL. Check LU.
Imperative: RT for LU.
GO LEFT
Inform/Prec: You're LUR Check LU
Imperative: Left for LU
DECR
You're Fast.
Attitude.
INCR
You're slow
Power
CONFIG
ASSUME CONTROL
ADVISE
RECOVERY SCAN
LSO TALKDOWN

Figure C I-3

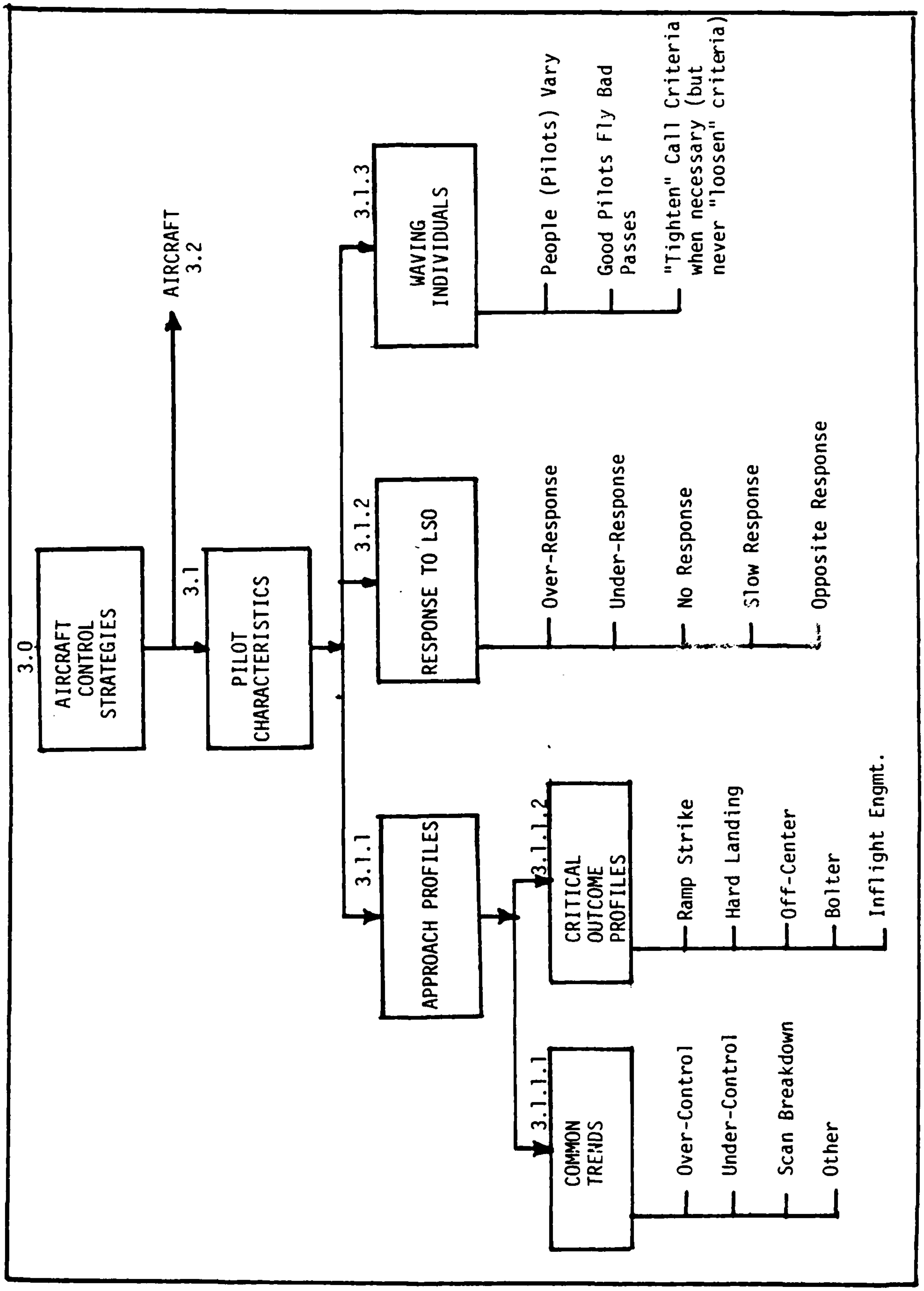

3.0
AIRCRAFT CONTROL STRATEGIES
3.1
PILOT CHARACTERISTICS
AIRCRAFT 3.2
3.1.1
APPROACH PROFILES
3.1.2
RESPONSE TO LSO
3.1.3
WAVING INDIVIDUALS
3.1.1.1
COMMON TRENDS
3.1.1.2
CRITICAL OUTCOME PROFILES
Over-Control
Under-Control
Scan Breakdown
Other
Ramp Strike
Hard Landing
Off-Center
Bolter
Inflight Engmt.
Over-Response
Under-Response
No Response
Slow Response
Opposite Response
People (Pilots) Vary
Good Pilots Fly Bad Passes
"Tighten" Call Criteria when necessary (but never "loosen" criteria)

Figure C I-4

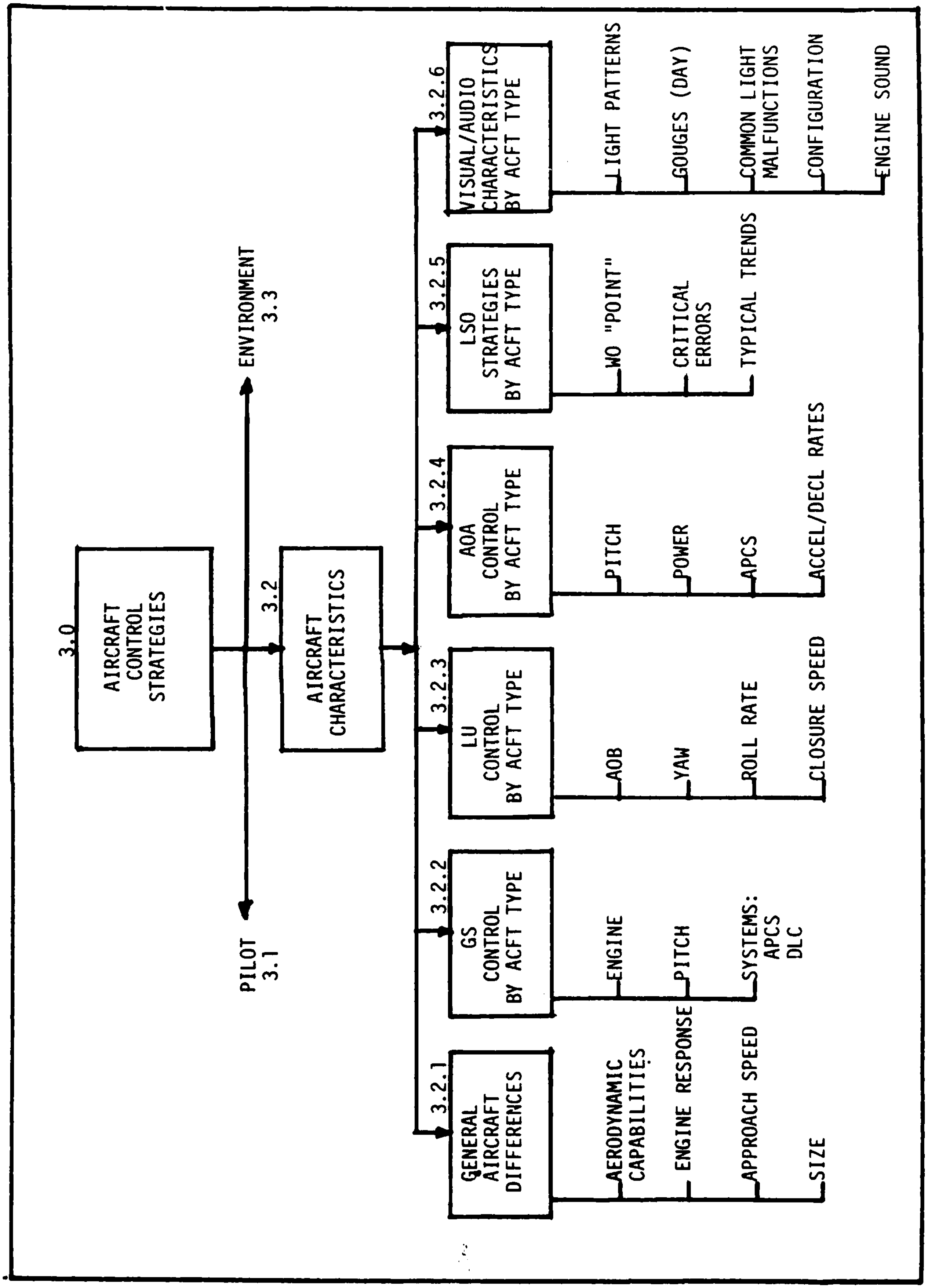

3.0
AIRCRAFT CONTROL STRATEGIES
PILOT 3.1
ENVIRONMENT 3.3
3.2
AIRCRAFT CHARACTERISTICS
3.2.1
GENERAL AIRCRAFT DIFFERENCES
AERODYNAMIC CAPABILITIES
ENGINE RESPONSE
APPROACH SPEED
SIZE
3.2.2
GS CONTROL BY ACFT TYPE
ENGINE
PITCH
SYSTEMS: APCS DLC
3.2.3
LU CONTROL BY ACFT TYPE
AOB
YAW
ROLL RATE
CLOSURE SPEED
3.2.4
AOA CONTROL BY ACFT TYPE
PITCH
POWER
APCS
ACCEL/DECL RATES
3.2.5
LSO STRATEGIES BY ACFT TYPE
WO "POINT"
CRITICAL ERRORS
TYPICAL TRENDS
3.2.6
VISUAL/AUDIO CHARACTERISTICS BY ACFT TYPE
LIGHT PATTERNS
GOUGES (DAY)
COMMON LIGHT MALFUNCTIONS
CONFIGURATION
ENGINE SOUND

Figure C I-5

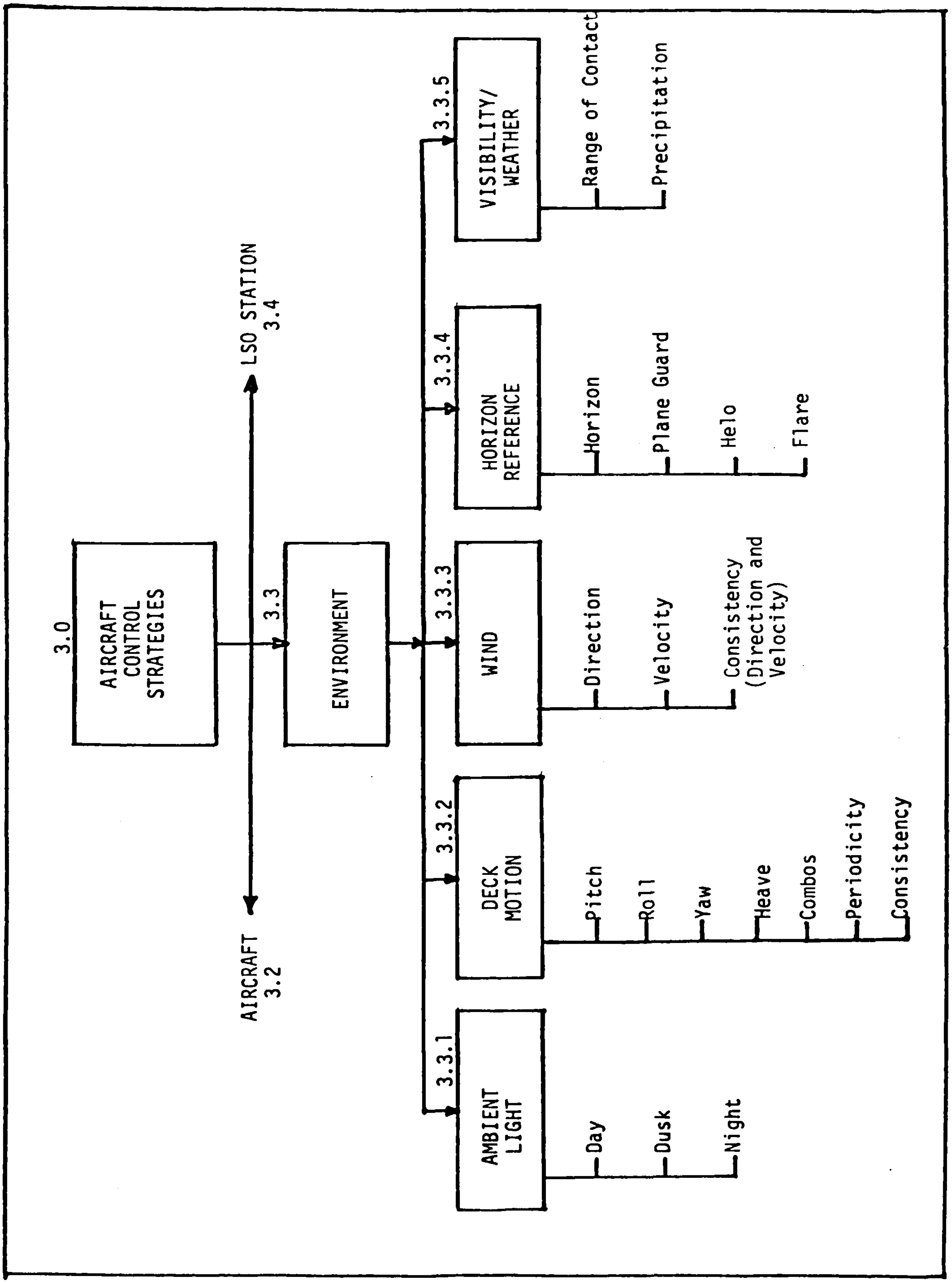

3.0
AIRCRAFT CONTROL STRATEGIES
3.3
ENVIRONMENT
AIRCRAFT 3.2
LSO STATION 3.4
3.3.1
AMBIENT LIGHT
Day
Dusk
Night
3.3.2
DECK MOTION
Pitch
Roll
Yaw
Heave
Combos
Periodicity
Consistency
3.3.3
WIND
Direction
Velocity
Consistency (Direction and Velocity)
3.3.4
HORIZON REFERENCE
Horizon
Plane Guard
Helo
Flare
3.3.5
VISIBILITY/ WEATHER
Range of Contact
Precipitation

Figure C.1-6

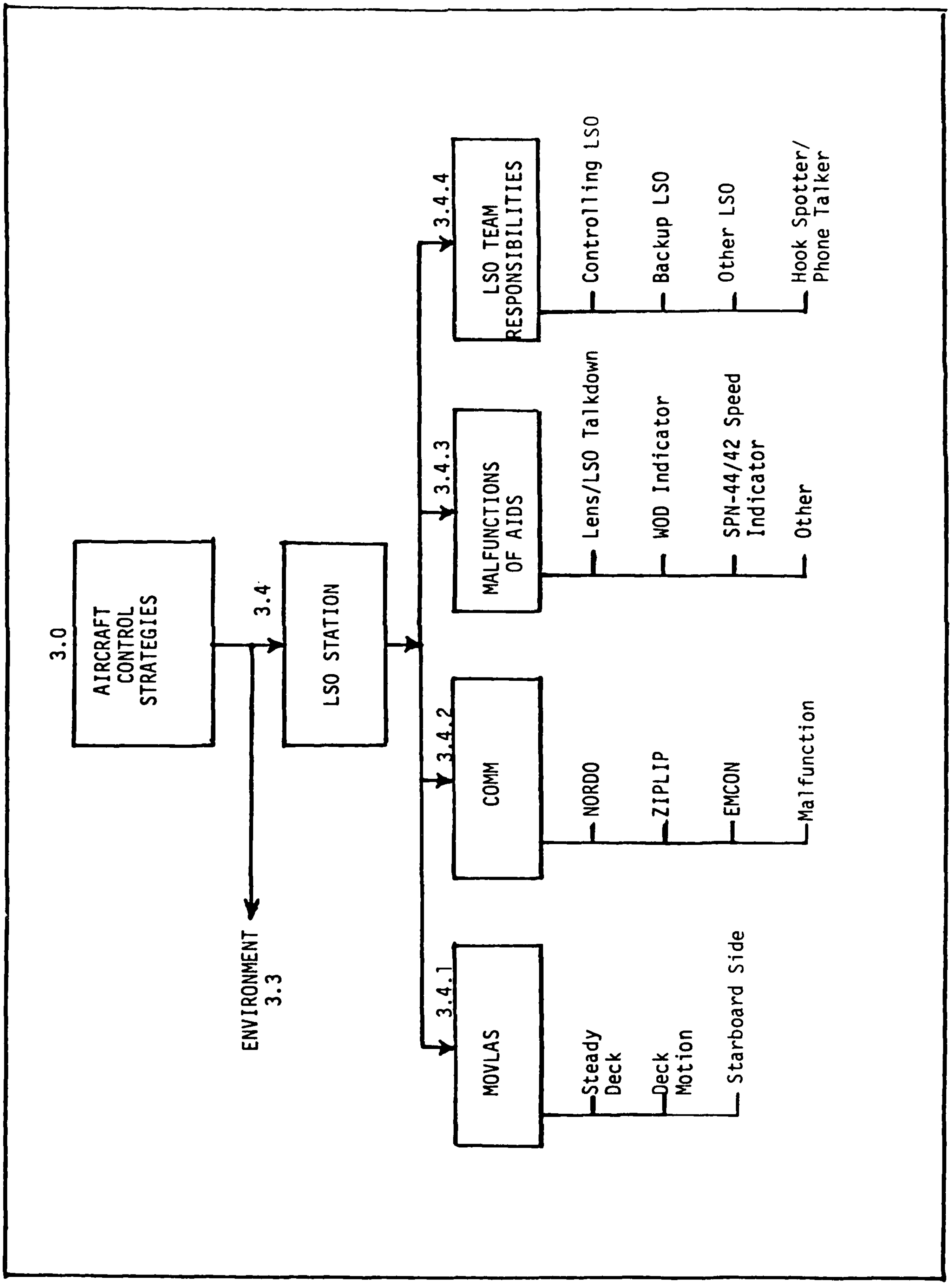

3.0
AIRCRAFT CONTROL STRATEGIES
3.4
LSO STATION
ENVIRONMENT 3.3
3.4.1
MOVLAS
Steady Deck
Deck Motion
Starboard Side
3.4.2
COMM
NORDO
ZIPLIP
EMCON
Malfunction
3.4.3
MALFUNCTIONS OF AIDS
Lens/LSO Talkdown
WOD Indicator
SPN-44/42 Speed Indicator
Other
3.4.4
LSO TEAM RESPONSIBILITIES
Controlling LSO
Backup LSO
Other LSO
Hook Spotter/ Phone Talker

Figure C 17

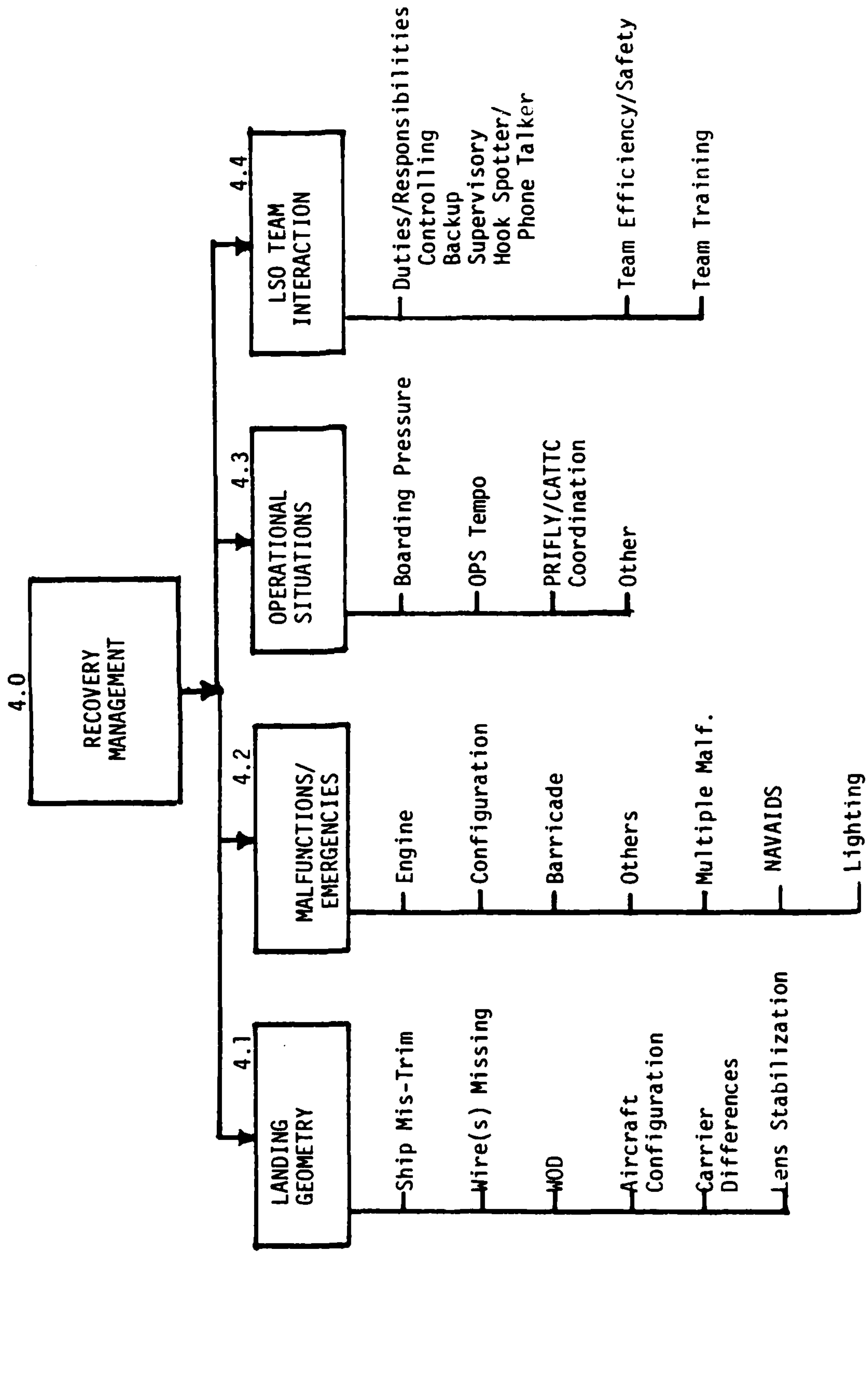

4.0
RECOVERY MANAGEMENT
4.1
LANDING GEOMETRY
Ship Mis-Trim
Wire(s) Missing
WOD
Aircraft Configuration
Carrier Differences
Lens Stabilization
4.2
MALFUNCTIONS/ EMERGENCIES
Engine
Configuration
Barricade
Others
Multiple Malf.
NAVAIDS
Lighting
4.3
OPERATIONAL SITUATIONS
Boarding Pressure
OPS Tempo
PRIFLY/CATTC Coordination
Other
4.4
LSO TEAM INTERACTION
Duties/Responsibilities
Controlling
Backup
Supervisory
Hook Spotter/
Phone Talker
Team Efficiency/Safety
Team Training

Figure C I-8

1.0 PERCEPTION

This instructional area is concerned with the basic perceptual skills required for waving approaches. The top level segmentations include the basic approach control dimensions of glideslope, lineup, AOA and range. Gross perception of closure speed variations, perception of basic aircraft configuration items and grading of approaches are also included.

1.0A Perceptual Scan

LSO scan breakdown (GS, LU, AOA cues) can lead to drastic deviation in one dimenson. A common LSO mistake is excess attention to GS at the expense of LU.

VAR: profiles (deviations)
responses

REQ: 1.1, 1.2, 1.3

1.1 Glideslope

1.1.1 Glideslope Position

Recognize glideslope position deviations.

VAR: profiles (GS deviations)

REQ:

1.1.2 Sink Rate

Detect sink rate variations associated with impending glideslope deviations.

VAR: profiles (GS deviations)

REQ:

1.1.3 Glideslope Corrections

Recognize sink rate variations associated with proper and improper glideslope deviation corrections.

VAR: profiles (GS deviations)
responses

REQ: 1.1.1, 1.1.2

1.2 Lineup

1.2.1 Lineup Position

Recognize lineup position deviations.

VAR: profiles (LU deviations)

REQ:

1.2.2 Drift Rate

Detect drift rate variations associated with impending lineup deviations.

VAR: profiles (LU deviations)
responses

REQ:

1.2.3 Lineup Corrections

Recognize drift rate variations associated with proper and improper lineup deviation corrections.

VAR: profiles (LU deviations)

REQ: 1.2.1, 1.2.2

1.3 AOA

1.3.1 AOA Deviations

Recognize deviations from optimum AOA.

VAR: profiles (AOA deviations)

REQ:

1.3.2 Impending AOA Deviations

Detect impending AOA deviations

VAR: profiles (AOA deviations)

REQ:

1.3.3 AOA Corrections.

Recognize proper and improper AOA deviation corrections

VAR: profiles (AOA deviations)
responses

REQ: 1.3.1, 1.3.2

1.4 Range

Recognize the functional range segments of an approach.

VAR: profiles

REQ:

1.5 Closure Speed

Recognize significant variation in aircraft approach speed.

VAR: profiles
aircraft configurations

REQ: 1.3

1.6 Configuration

Recognize proper and improper basic aircraft landing configurations.

VAR: aircraft configurations
aircraft types

REQ:

1.7 Grading Approaches

1.7A Perceptual Deception

LSO can become perceptually "deceived" by a smooth approach with a minor deviation (such as little high). This can negatively affect critical perceptions in close and can also hurt LSO credibility during debrief. This deception can also be brought on by a series of smooth approaches with some deviation. Over a period of time, pilots will try to fly the type of approach that they think the LSO wants to see for an OK grade.

VAR: profiles

REQ: 1.1, 1.2, 1.3

1.7.1 Recall

Recall significant characteristics of approaches.

VAR: profiles
responses

REQ: 1.1, 1.2, 1.3, 1.4
Approach terminology, symbology

1.7.2 Grades

Assign qualitative grades to approaches.

VAR: profiles
responses

REQ: 1.1, 1.2, 1.3, 1.4

2.0 BASIC AIRCRAFT CONTROL

This instructional area is concerned with LSO association of perceptual cues to the use of voice calls and light signals (cut, waveoff) for waving (controlling) approaches. This block is intended to develop within the trainee a basic cognitive foundation for waving approaches in relatively sterile situations. Primary emphasis is upon control of glideslope, lineup and AOA and proper initiation of the waveoff. However, this block also addresses commands for proper aircraft configuration, assumption of LSO control, advisories concerning recovery conditions and required scan/monitoring responsibilities of the LSO.

2.0A Voice Call Strategy

As a general voice call strategy, informative calls are used early in an approach and imperative calls are used late in the approach.

VAR: profiles

REQ: voice calls
light signals
1.1, 1.2, 1.3, 1.4

2.1 Glideslope

Initiate appropriate voice calls/light signals for existing or impending glideslope deviations.

VAR: profiles (GS deviations)

REQ: 1.1, 1.4
voice calls
light signals

2.1A "Go For It" Calls

Do not use calls that can be misinterpreted by the pilot as "go for it".

VAR: profiles (GS deviations)

REQ: 1.1

2.1.1 Glideslope Criteria

Recognize glideslope call/signal criteria.

VAR: profiles (GS deviations)

REQ: 1.1, 1.4

2.1.1A Sink Rate and Lineup Corrections

Be prepared for sink rate increases during late lineup corrections.

VAR: profiles (GS and LU deviations)

REQ: 1.1, 1.2

2.2 Lineup

Initiate appropriate voice calls for existing or impending lineup deviations.

VAR: profiles (LU deviations)

REQ: 1.2, 1.4
voice calls

2.2.1 Lineup Criteria

Recognize lineup call criteria.

VAR: profiles (LU deviations)

REQ: 1.2, 1.4

2.3 AOA

Initiate appropriate voice calls/light signals for existing or impending AOA deviations.

VAR: profiles (AOA deviations)

REQ: 1.3, 1.4
voice calls
light signals

2.3.1 AOA Criteria

Recognize AOA call/signal criteria.

VAR: profiles (AOA deviations)

REQ: 1.3, 1.4

2.4 Waveoff

Initiate waveoff call/signal when appropriate during approach.

VAR: profiles (requiring waveoff)

REQ: 1.1, 1.2, 1.3, 1.4

2.4A Waveoff Actions

Always use waveoff call and pickle simultaneously when waveoff is required.

VAR: profiles (requiring waveoff)

REQ: 1.1, 1.2, 1.3, 1.4

2.4B Waveoff Call

The waveoff call must be given firmly but calmly. An over-excited call may lead to excessive pitch response from the pilot and an inflight engagement.

VAR: profiles requiring late waveoff

REQ: 1.1, 1.2, 1.3, 1.4

2.4.1 Waveoff Criteria

Recognize waveoff criteria.

VAR: profiles (requiring waveoff)
deck status

REQ: 1.1, 1.2, 1.3, 1.4

2.4.1A Criteria-Inside Waveoff Point

Inside the normal waveoff point, use waveoff any time deck goes foul and any time 100% power is needed for aircraft to clear ramp (however, the latter may be controversial).

VAR: profiles
deck status

REQ: 1.1, 1.2, 1.3, 1.4

2.4.1B Criteria-Multiple Deviations

For significant multiple deviations in close, a waveoff should be used by the LSO. As a rule of thumb, if 2 major deviations (from among GS, LU, AOA or power) are AFU approaching the waveoff point, use waveoff. This is especially critical with CQ pilot.

VAR: profiles requiring waveoff

REQ: 1.1, 1.2, 1.3, 1.4

2.4.1C Criteria - Unsettled Dynamics

For unsettled dynamics (speed, power, wing position, flight vector, pitch) in close, LSO should consider giving a waveoff.

VAR: profiles requiring waveoff

REQ: 1.1, 1.2, 1.3, 1.4

2.4.1D Criteria - High at Ramp, Low Sink Rate

High at the ramp with less than optimum rate of descent can lead to a dangerous long bolter. Do not hesitate to use waveoff.

VAR: profiles requiring waveoff

REQ: 1.1, 1.4

2.4.1E Criteria - High at Ramp, High Sink Rate

High at the ramp with excessive rate of descent can easily result in a hard landing.

VAR: profiles requiring waveoff

REQ: 1.1, 1.4

2.4.1F Criteria - Men or Aircraft in Landing Area

Move the waveoff point out when there are men on deck or aircraft in landng area.

VAR: deck status
profiles

REQ: 2.1, 2.2, 2.3

2.5 Other Aircraft Control Requirements

2.5.1 Configuration

Initiate appropriate calls to assist pilot in properly configuring aircraft.

VAR: aircraft configurations

REQ: 1.6

2.5.1A Improper Approach Light

Do not accept an aircraft without an approach light or with a flashing approach light. If possible, ask pilot to check gear or hook (as appropriate) well prior to ball call.

VAR: approach light variations

REQ: 1.6

RELATED: 4.4B

2.5.2 Assume Control

Assume LSO control of approach at appropriate time.

VAR: profiles

REQ: 1.4

2.5.2A Roger Ball, Paddles Contact

A calm and confident sounding "Roger Ball" (or "Paddles Contact") is critical to pilot confidence in LSO. An excitable or unconfident sounding call may have a negative effect on subsequent pilot responsiveness.

VAR: response
profiles

REQ: 1.1, 1.2, 1.3, 1.4

2.5.2B Paddles Contact

If the pilot is flying poorly and if CCA is well out of limits, use "Paddles Contact" or directional calls inside 2 miles to help avoid an extremely poor start.

VAR: profiles (poor CCA)

REQ: 2.1, 2.2

2.5.3 Approach/Recovery Advisories

Provide appropriate approach/recovery advisories to assist pilot.

VAR: wind
deck motion
MOVLAS
ship turn

REQ: 2.1, 2.2, 2.3, 2.4

2.5.4 Recovery Scan

Scan/monitor the landing area and relevant displays at appropriate intervals during the recovery process and individual approaches (this includes deck status).

VAR: deck status
BU LSO calls
LSO indicators

REQ:

2.5.4A Landing Area

Move the waveoff point out when there are men on deck or aircraft in landing area.

VAR: deck status
profiles

REQ: 2.4

RELATED: 2.4.1F

2.5.5 LSO Talkdown

Demonstrate ability to provide pilot with an "LSO Talkdown."

VAR: profiles
responses

REQ: 2.1, 2.2, 2.3, 2.4

3.0 AIRCRAFT CONTROL STRATEGIES

This instructional area is concerned with more advanced waving skills. This block is intended to expand the trainee's basic cognitive processing skills to handle the major influences upon LSO decisions during an approach. Additional perceptual and decision factors are introduced to the trainee to enable him to wave approaches in a multitude of increasingly complex situations. Each of the top level segmentations within this block (PILOT, AIRCRAFT, etc.) is concerned with a logical grouping of waving situation variables.

3.0A LSO Involvement In Pass

Try to wave such that the pilot makes his own corrections. When his performance or recovery conditions start deteriorating, you must increase your involvement in the pass.

VAR: profiles
responses
deck motion
wind
ambient light
visibility
horizon reference

REQ: 2.0

3.1 Pilot Characteristics

Demonstrate ability to wave variations in pilot characteristics.

VAR: profiles
responses

REQ: 2.0

3.1A Salvaging An Approach

LSO should never assume that a pilot can salvage an approach without LSO help.

VAR: profiles
pilot responses

REQ: 2.0

3.1B Assumption - Pilot Correction

LSO should never assume that pilot will make proper correction for a given deviation.

VAR: profiles
responses

REQ: 2.0

3.1C Disoriented/Fatigued Pilot

For a disoriented pilot (i.e. vertigo) or one suffering from fatigue, LSO may have to "climb into cockpit" (i.e. LSO talkdown) to effect a safe recovery (however, do not stay there if you do not have to).

VAR: profiles
response

REQ: 2.0

3.1D Low Pilot Proficiency

Low proficiency in pilots tends to be evidenced by poor starts and overcontrolling everything all the way.

VAR: profiles
responses

REQ: 2.0

3.1E Deck Spotting

Early wires over a period of time by the same pilot is indicative of "deck-spotting".

VAR: profiles

REQ: 2.1, 2.4

3.1.1 Approach Profiles

3.1.1.1 Common Approach Profiles

Initiate appropriate voice calls/light signals in response to common approach profile trends.

VAR: profiles

REQ: 2.0

3.1.1.1A Settle on Lineup Correction

LSO must be alert for a settle on lineup correction. A "power" call prior to the lineup call should be considered when aircraft is approaching in close.

VAR: profiles (GS and LU deviations)

REQ: 2.1, 2.2

3.1.1.1B CQ Pilot Scan

During CQ, pilot scan is usually slow, therefore, be extremely cautious of multiple deviations in-the-middle to in-close.

VAR: profiles
responses (slow)

REQ: 2.0

RELATED: 4.3.1D

3.1.1.1C Low Trend

LSO should never accept a low trend on an approach.

VAR: profiles
responses (slow)

REQ: 2.1, 2.4

3.1.1.1D High Trend

LSO should not accept a high trend on an approach.

VAR: profiles
responses (slow)

REQ: 2.1, 2.4

3.1.1.1E Poor Start

During day recoveries, beware of pilot tendency to try and salvage an extremely poor start (i.e. OSX, NESA HFX, HFX, etc.). If not stable approaching in close position, use waveoff.

VAR: profiles

REQ: 2.0

3.1.1.1.1 Recognize Trends

Recognize common approach profile trends.

VAR: profiles

REQ: 2.0

3.1.1.1.1A Pilot Fixation

A typical pilot error is fixation on cues for one dimension (i.e. lineup) at the expense of another dimension (i.e. glideslope).

VAR: profiles

REQ: 2.0

3.1.1.1.1B Poor Start-Disorientation

Poor trends leading to the start and at the start are good indicators that the pass is going to be a problem due to pilot disorientation or poor pilot scan.

VAR: profiles (poor CCA and start)

REQ: 2.0

3.1.1.1.1C Poor Start-Overcontrol

A poor start frequently leads to overcontrol tendencies in the remainder of the pass.

VAR: profiles (poor start)
responses (overcontrol)

REQ: 2.0

RELATED: 3.1.2.1B

3.1.1.1.1D Moth Effect

Be alert for the "moth effect" (drift left in close or at the ramp) due to pilot fixation on the meatball at the expense of lineup control.

VAR: profiles (LU deviations)

REQ: 2.0

3.1.1.1.1E Poor Start

A major glideslope deviation at the start to in the middle is difficult for the pilot to salvage. Extra LSO assistance may be needed to help pilot get aboard.

VAR: profiles (deviations X-IM)
responses

REQ: 2.0

3.1.1.2 Critical Outcome Profiles

Initiate appropriate voice calls/light signals in response to critical outcome profile trends.

VAR: profiles (critical)

REQ: 3.1.1.1

3.1.1.2.1 Recognize Critical Profiles

Recognize critical outcome profile trends.

VAR: profiles (critical)

REQ: 3.1.1.1

3.1.1.2.1A Criticality of High Deviation

More ramp strikes occur when pilot is correcting for a high deviation in close than for a low deviation.

VAR: profiles (critical-high to rampstrike)

REQ: 3.1.1.1

3.1.1.2.1B Long Bolter

High at the ramp with less than optimum rate of descent can lead to a dangerous long bolter. Do not hesitate to use waveoff.

VAR: profiles (critical-high to bolter)

REQ: 3.1.1.1

RELATED: 2.4.1D

3.1.1.2.1C High, Coming Down

High at the ramp with excessive rate of descent can easily result in a hard landing.

VAR: profiles (critical - high to comedown)

REQ: 3.1.1.1

RELATED: 2.4.1E

3.1.2 Pilot Response

Initiate appropriate voice calls/light signals in response to undesireable pilot responses to LSO actions.

VAR: profiles
response

REQ: 2.0

3.1.2A Waveoff, Slow Response

If LSO notes slow pilot responsiveness approaching in close, use waveoff earlier for critical deviations.

VAR: profiles (deviations in close)

REQ: 2.4

3.1.2B Assumption - Pilot Response

LSO should never assume that the pilot will make correct response to LSO call in close. Be prepared to follow up the call with waveoff.

VAR: profiles (deviations in close)
responses (slow, none)

REQ: 2.0

3.1.2C Waveoff, Unresponsive Pilot

Waveoff point should be moved out for unresponsive pilot.

VAR: profiles requiring waveoff
responses (slow, none)

REQ: 2.4

3.1.2D Response to Attitude Calls

If one attitude call does not get sufficient pilot response, switch to a power call (or waveoff, if needed).

VAR: response (slow, none)
profiles (low/slow/comedown in close)

REQ: 2.1, 2.4

3.1.2.1 Recognize Responses

Recognize undesireable pilot responses to LSO actions.

VAR: profiles requiring LSO calls
response

REQ: 2.0

3.1.2.1A Response to Power Calls

After about 2 or 3 power calls without sufficient pilot response, the waveoff should be used.

VAR: response (slow, none)
profiles (low/slow/comedown - requiring waveoff)

REQ: 2.1, 2.4

3.1.2.1B Poor Start - Overcontrol

A poor start frequently leads to overcontrol tendencies in the remainder of the pass.

VAR: response (overcontrol)
profiles (poor start, overcontrol)

REQ: 2.0

RELATED: 3.1.1.1.1C

3.1.3 Waving Individuals

Demonstrate an awareness of variations in pilot skill levels and tendencies.

VAR: "a priori" knowledge of pilot (experience, proficiency, skill, tendencies, condition)
profiles
responses

REQ: 3.1.1, 3.1.2

3.1.3A Pilot Experience

LSO should consider very inexperienced pilot as especially unpredictable, however, LSO should not "lower his guard" for highly skilled or experienced pilots. They will occasionally make critical, unpredictable errors requiring waveoffs.

VAR: responses
profiles requiring waveoff
"a priori" knowledge of pilot (experience, skill)

REQ: 2.4

3.1.3B Past Pilot Performance

The quality level of a pilot's past performance (FCLP or CV ops) is no guarantee of the same on any given approach.

VAR: "a priori" knowledge of pilot (skill)
profiles
response

REQ: 2.0

3.1.3C Multiple Approach Attempts

The pilot who experiences more than 2 passes (possibly excluding foul deck waveoffs) to get aboard has a higher probability of making radical corrections in-close to in-the-wires.

VAR: profiles (deviations in close)
response

REQ: 2.0

3.1.3D Waveoff, Disoriented Pilot

Waveoff point should be moved out for disoriented pilot

VAR: "a priori" knowledge of pilot (condition)
profiles requiring waveoff
responses

REQ: 2.0

3.1.3E Waveoff, Unproficient Pilot

LSO should consider moving waveoff point out slightly for a pilot known to be unproficient.

VAR: "a priori" knowledge of pilot (proficiency)
profiles requiring waveoff
responses

REQ: 2.4

3.2 Aircraft Characteristics

Adjust voice call/light signal criteria for variations in performance among different types of aircraft.

VAR: aircraft types
profiles
responses

REQ: 2.0

3.2.1 General Aircraft Differences

Demonstrate an awareness of general differences among aircraft types, in terms of performance and visual/audio characteristics.

3.2.2 Glideslope Control By Aircraft Type

Demonstrate ability to adjust voice call/light signal criteria for glideslope control differences among aircraft types.

3.2.2A Slow Engine Response

If calls are necessary for aircraft with slow engine response (A-7, S-3, F-14), they must be given well prior to glideslope interception when correction is being made for a high deviation.

VAR: aircraft type (A-7, S-3, F-14)
profiles (high comedown)
responses

REQ: 2.0, 3.1.2

3.2.2B Excellent Engine Response

For aircraft with excellent engine response (A-6, EA-6B, F-4), be alert for pilot overcontrol of power. This also includes excessive power reductions following too much power.

VAR: aircraft type (A-6, EA-6B, F-4)
profiles (GS deviations, overcontrol)
responses (overcontrol)

REQ: 2.0, 3.1.1, 3.1.2

3.2.2C A-7, F-14, High, Fast, Comedown

For A-7 and F-14, HFIM-IC trend is potentially disastrous due to DEC CD potential.

VAR: aircraft type (A-7, F-14)
profiles (high, comedown)
responses

REQ: 2.0, 3.1.1, 3.1.2

3.2.2D A-7, High Comedown

For A-7, do not allow HCDIC trend. Excess sink rate is difficult to stop with power due to poor engine response.

VAR: aircraft type (A-7)
profiles (high, comedown)
responses

REQ: 2.0, 3.1.1, 3.1.2

3.2.2E A-6, Settle On Lineup Correction

For A-6 beware of settle on lineup correction when aircraft is LOSLOIC.

VAR: aircraft type (A-6)
profiles (GS & LU deviations)

REQ: 2.0

3.2.2F F-4, Nose Movement, Power Reduction

For F-4, do not allow significant nose movement and/or power reduction, especially for HIC deviation. An extremely high sink rate can result.

VAR: aircraft type (F-4)
profiles (pitch, power deviations)
responses

REQ: 2.0, 3.1.1, 3.1.2

3.2.2G F-14, High Nose Down With APCS

For F-14, in a HNDIC situation with APCS, excessive sink rate will result. Attitude correction will not be adequate, therefore use power call(s).

VAR: aircraft type (F-14)
approach mode (APCS)
profiles (high, nose down in close)
responses

REQ: 2.1, 2.4, 3.1.1, 3.1.2

3.2.2H A-7, Low, Flat pass

For A-7, a LOB pass requires critical nose finesse to avoid bolter or ramp strike.

VAR: aircraft type (A-7)
profiles (low trends)
responses (overcontrol, undercontrol)

REQ: 2.1, 2.4, 3.1.1

3.2.2I EA-6B, Nose Sensitivity

For EA-6B, glideslope control is very sensitive to nose movement. This sensitivity can also lead to a decel.

VAR: aircraft type (EA-6B)
profiles (GS, AOA, pitch, power deviations)
responses

REQ: 2.1, 2.3, 2.4, 3.1.1, 3.1.2

RELATED: 3.2.4C

3.2.2J S-3, Glideslope Control Through Burble

For S-3, aircraft glideslope control through the "burble" is difficult under high WOD conditions.

VAR: aircraft type (S-3)
wind (high)
profiles (GS deviations)

REQ: 2.1, 2.4

RELATED: 3.3.3C

3.2.2K S-3, F-14, DLC and Drop Nose

For S-3 and F-14, beware of a drop nose in conjunction with DLC activation in close. Excessive sink rate will result.

VAR: aircraft type (S-3, F-14)
profiles (high, drop nose in close)
approach mode (DLC)

REQ: 2.1, 2.4, 3.1.1

3.2.2L S-3, DLC for High Deviations

For S-3, use of DLC is good for high deviations and avoiding large power reductions except when approaching "at the ramp" area.

VAR: aircraft type (S-3)
approach mode (DLC)
profiles (high deviations)

REQ: 2.1, 2.4, 3.1.1

3.2.2M S-3, Without DLC

For S-3, without DLC, nose pitch is very sensitive to power changes.

VAR: aircraft type (s-3)
responses
approach mode (no DLC)

REQ: 2.1, 2.3, 2.4, 3.1.1, 3.1.2

3.2.2N F-14, Without DLC

For F-14, without DLC engaged, aircraft is farther back on power than normal, thus resulting in reduced engine responsiveness.

VAR: aircraft type (F-14)
approach mode (no DLC)
profiles (requiring power calls)
responses

REQ: 2.1, 2.3, 2.4, 3.1.2

3.2.3 Lineup Control by Aircraft Type

Demonstrate ability to adjust voice call criteria for lineup control differences among aircraft types.

3.2.3A S-3, E-2, Lineup Control

Lineup control for "slow movers" (i.e., S-3, E-2) is more critical in shifting wind conditions than for "fast movers".

VAR: aircraft type (S-3, E-2)
profiles (LU deviations)
wind (shifting)

REQ: 2.2, 3.1.1

3.2.3B Lineup for Large Aircraft

Large wing-span aircraft (i.e., E-2, S-3, F-14, etc.) must be on lineup and have little or no drift by the in close position.

VAR: aircraft type (E-2, S-3, F-14)
profiles (LU deviations)
responses

REQ: 2.2, 2.4, 3.1.1

3.2.3C F-4S, Lineup Control

Lineup corrections are difficult with F-4S due to reduced lateral control effectiveness.

VAR: aircraft type (F-4S)
profiles (LU deviations)
responses

REQ: 2.2, 2.4, 3.1.1, 3.1.2

3.2.4 AOA Control By Aircraft Type

Demonstrate ability to adjust voice call/light signal criteria for AOA control differences among aircraft types.

3.2.4A APCS, High Wind

APCS should not be used in high wind conditions (greater than 35 knots).

VAR: aircraft types
approach mode (APCS)
wind (high)
profiles
response

REQ: 2.1, 2.3, 3.1.1, 3.1.2

RELATED: 3.3.3A

3.2.4B F-4, A-7 Closure Speed, Light WOD

For F-4 and A-7, due to normally high approach speed, must pay close attention to closure under light WOD conditions.

VAR: aircraft type (F-4, A-7)
wind (low)
profiles (AOA deviations)

REQ: 2.3, 2.4

RELATED: 3.3.3B

3.2.4C EA-6B Nose Sensitivity

For EA-6B, glideslope control is very sensitive to nose movement. This sensitivity can also lead to a decel.

VAR: aircraft type (EA-6B)
profiles (GS, AOA deviations)
responses

REQ: 2.1, 2.3, 2.4, 3.1.1, 3.1.2

RELATED: 3.2.2I

3.2.5 LSO Strategies by Aircraft Type

Demonstrate awareness of differences in waveoff "point", critical errors, and typical trends among aircraft types.

3.2.5A APCS Disengagement

For aircraft which have difficult APCS disengagement, waveoff point should be moved out slightly.

VAR: aircraft type
profiles requiring waveoff
responses

REQ: 2.1, 2.4

3.2.5B Long Fuselages, Inflight Engagements

EA-6B, E-2 and F-14 have long fuselages, therefore potential for inflight engagement.

VAR: aircraft type (EA-6B, E-2, F-14)
profiles (late waveoff requirements)
responses (slow, overreact to WO)

REQ: 2.1, 2.3, 2.4

3.2.6 Visual/Audio Characteristics of Different Aircraft Types

3.2.6A Lighting Malfunctions

With less than optimum lighting configuration, LSO range discrimination is degraded, thus causing difficulty in determining a safe waveoff point (for both technique and foul deck waveoffs).

VAR: aircraft lighting malfunctions
profiles requiring waveoff
responses

REQ: 2.4

3.2.6B Lighting Malfunctions

For an aircraft with only a single light visible, consider having the NFO use his flashlight as an extra reference. Also consider having CATCC or B/U LSO provide range calls.

VAR: aircraft lighting malfunction
profiles

REQ: 2.0

3.3 Environmental Factors

Adjust voice call/light signal criteria for variations in environmental conditions.

3.3.1 Ambient Light

Adjust voice call/light signal criteria for all variations in ambient light conditions (day, dusk, night).

VAR: ambient light
profiles
responses
aircraft types

REQ: 2.0

3.3.2 Deck Motion

Adjust voice call/light signal criteria for variations in deck motion conditions.

VAR: deck motion
profiles
responses
MOVLAS
ambient light

REQ: 2.0

3.3.2A Voice Calls, MOVLAS, Pitching Deck

More LSO calls than usual should be made when MOVLAS is in use with pitching deck conditions.

VAR: MOVLAS
deck motion
profiles
responses

REQ: 2.0

RELATED: 3.4.1C

3.3.2B Pitching Deck, High In Close

With pitching deck conditions, be very hesitant to accept a high deviation in close.

VAR: profiles (high deviations in close)
deck motion

REQ: 2.1, 2.4

3.3.2C Plane Guard Positioning

When there is no horizon and deck is moving, have plane guard destroyer or helo positioned aft of the ship near final bearing to aid glideslope reference.

VAR: horizon reference
deck motion
profiles (GS deviations)
ambient light

REQ: 2.1, 2.4, 3.3.1

RELATED: 3.3.4A

3.3.2D Waveoff, Deck Motion

When deck is moving, move waveoff window out.

VAR: deck motion
profiles requiring waveoff
responses

REQ: 2.4

3.3.2E Predicting Deck Cycle

With no visible horizon use dynamic hook-to-ramp indicator to help predict deck pitch cycle; however, remember that there is some lag in the indication.

VAR: horizon reference
deck motion
hook-to-ramp indicator
profiles
ambient light
CLASS indicator

REQ: 2.0, 3.3.1

RELATED: 3.3.4B

3.3.2F Voice Calls, Deck Motion

When deck is moving, LSO must make more voice calls than usual.

VAR: deck motion
profiles
responses
ambient light

REQ: 2.0, 3.1.1, 3.1.2

3.3.2G Deck Motion, Lineup In Close

When aircraft is lined up left in close, it is easy for the controlling LSO to lose track of deck motion cycle.

VAR: profiles (LU & GS deviations in close)
deck motion
ambient light

REQ: 2.2, 2.5.4, 3.1.1

3.3.2H Dutch-roll

When deck is moving, be alert for "dutch-roll" which affects lineup as well as glideslope.

VAR: deck motion
profiles (GS & LU deviations)
responses
ambient light

REQ: 2.1, 2.2, 2.4, 3.1.1, 3.1.2

3.3.3 Wind Over Deck

Adjust voice call/light signal criteria for variations in recovery wind conditions.

VAR: wind
profiles
responses
aircraft types

REQ: 3.1, 3.2

3.3.3A APCS - High Winds

APCS should not be used in high wind conditions (greater than 35 knots).

VAR: aircraft type
approach mode
wind
profiles
responses

REQ: 2.1, 2.3, 2.4, 3.1.2, 3.2

RELATED: 3.2.4A

3.3.3B High Approach Speed, Low WOD

For F-4 and A-7, due to normally high approach speed, must pay close attention to closure under light WOD conditions.

VAR: aircraft type
approach mode
wind
profiles
response

REQ: 2.3, 2.4

RELATED: 3.2.4B

3.3.3C S-3, High WOD

For S-3, aircraft glideslope control through the "burble" is difficult under high WOD conditions.

VAR: aircraft type
wind
profiles
responses

REQ: 2.1, 2.4, 3.2.2, 3.1.2

RELATED: 3.2.2J

3.3.3D High WOD

With a high WOD situation (35 knots or more) aircraft dynamics can rapidly deteriorate to a settle in close with only slight power or aircraft attitude changes.

VAR: wind
profiles
responses

REQ: 2.1, 2.4, 3.1.2

3.3.3E Low WOD

With a low WOD situation (less than 25 knots), the high closure rate does not allow much margin for salvaging a come down or settle in close, therefore, move waveoff window out.

VAR: wind
profiles
responses

REQ: 2.1, 2.4, 3.1.2

3.3.3F Crosswind

Starboard crosswind causes increased sink rates at the ramp.

VAR: wind
profiles

REQ: 2.1, 2.2, 2.4

3.3.3G Crosswind

Crosswind conditions can cause rapid drift rates in close and at the ramp.

VAR: wind
profiles

REQ: 2.2, 2.4

3.3.3H Crosswind

During crosswind conditions be prepared for increased sink rates with late lineup conditions.

VAR: wind
profiles

REQ: 2.1, 2.2, 2.4

3.3.3I Low WOD

LSO (or B/U) must continually check closure speed to insure adherence to max engaging speeds, especially under low WOD conditions.

VAR: speed indicators
wind
profiles
responses

REQ: 2.3, 2.4

RELATED: 4.4G

3.3.3J Abnormal WOD Advisory

LSO should inform pilot of abnormal WOD conditions.

VAR: wind

REQ: 2.5.3

3.3.4 Horizon Reference

Adjust voice call/light signal criteria for variations in availability of horizon reference.

VAR: horizon reference
profiles

REQ: 3.3.1, 2.0

3.3.4A Plane Guard Position, No Horizon

When there is no horizon and deck is moving, plane guard destroyer or helo positioned aft of the ship near final bearing can aid glideslope reference.

VAR: horizon reference
deck motion
profiles
ambient light

REQ: 2.1, 2.4, 3.3.1, 3.3.2

RELATED: 3.3.2C, 4.3.2F

3.3.4B Deck Motion, No Horizon

With no visible horizon use dynamic hook-to-ramp indicator to help predict deck pitch cycle; however, remember that there is some lag in the indication.

VAR: horizon reference
deck motion
hook-to-ramp indicator
profiles
ambient light

REQ: 2.0, 3.3.1

RELATED: 3.3.2E

3.3.4C No Horizon

With no horizon reference available, use other means (HUD, SPN-42) to insure proper eyeball calibration.

VAR: horizon reference
glideslope indicators
profiles
ambient light

REQ: 2.5.4, 3.3.1

3.3.5 Visibility

Adjust voice call/light signal criteria to variations in visibility conditions.

VAR: visibility
profiles
responses

REQ: 2.0, 3.1.1, 3.1.2

3.3.5A Reduced Visibility

For reduced visibility situation with a late breakout (inside 3/4 mile), LSO must track aircraft positioning and trends with whatever means are available (SPN 42, LSO HUD, listen to CCA calls, etc.) so that there are no surprises and the LSO is prepared to give timely aid to the pilot (or make a timely waveoff decision).

VAR: visibility
profiles
responses

REQ: 2.0, 3.1.1, 3.1.2

3.3.5B Reduced Visibility, LSO Talkdown

LSO talkdown may be required when pilot visibility is reduced by sun/moon glare, smoke in the groove, rain, canopy fog, etc. If pilot can not see by 1/4 - 1/2 mile, he should waveoff or be waved off.

VAR: profiles
responses

REQ: 2.0

3.3.5C Reduced Visibility

Under reduced visibility conditions, the pilot has more difficulty seeing visual landing aids than LSO does seeing aircraft. Be prepared to provide extra assistance.

VAR: visibility
profiles
responses

REQ: 3.0

3.4 LSO Station

3.4.1 MOVLAS

Demonstrate ability to recover aircraft using MOVLAS

VAR: profiles
response
deck motion
ambient light
aircraft types
MOVLAS

REQ: 2.0, 3.1

3.4.1A MOVLAS Advisory

Insure pilots are informed when MOVLAS is in use.

VAR: MOVLAS

REQ: 2.5.3

3.4.1B MOVLAS Technique

MOVLAS must be moved enough to enable pilot discrimination of ball movement

VAR: MOVLAS
profiles

REQ: 1.1

3.4.1C MOVLAS Technique

More LSO calls than usual should be made when MOVLAS is in use with pitching deck conditions.

VAR: MOVLAS
deck motion
profiles

REQ: 2.0

RELATED: 3.3.1C

3.4.1D "High Eye" Tendency with MOVLAS

The LSO must avoid the tendency for a "high eye" when using MOVLAS.

VAR: MOVLAS
profles

REQ: 1.1

3.4.1E Waveoff Decision, MOVLAS

When working MOVLAS, do not delay the waveoff decision. Remember that you are busier than usual.

VAR: MOVLAS
profiles requiring waveoff

REQ: 2.4

3.4.1F Starboard Side MOVLAS

With a starboard side MOVLAS, expect some breakdown in pilot scan.

VAR: MOVLAS
profiles
responses

REQ: 3.1

RELATED: 4.3.1J

3.4.2 Communications

Demonstrate ability to recover aircraft under constrained communications situations.

VAR: NORDO/malfunction
ZIPLIP, EMCON
profiles
responses

REQ: 2.0

3.4.2A NORDO, Waveoff Decision

For a NORDO aircraft, move waveoff window out.

VAR: profiles
NORDO
responses

REQ: 2.4

3.4.2B LSO Actions with NORDO

For a NORDO aircraft, always use voice calls and emergency UHF override anyway, in addition to light signals.

VAR: profiles
responses
NORDO

REQ: 2.0

3.4.2C ZIPLIP/EMCON

Under ZIPLIP/EMCON conditions, safety is still paramount, therefore, do not hesitate to use voice calls as needed.

VAR: profiles
responses
ZIPLIP
EMCON

REQ: 2.0

3.4.3 Malfunctions of LSO Job Aids

Demonstrate ability to recover aircraft with existing malfunctions of LSO job aids (indicators)

VAR: LSO workstation displays
profiles
wind
deck motion
aircraft configurations
aircraft types

REQ: 3.2

3.4.3A No Speed Indicator

If closure speed readout is not avalable on the platform, consider asking for speed calls from Air Boss or CATCC.

VAR: speed indicators
wind

REQ: 1.3, 1.5, 2.5.4

RELATED: 4.3.2G

3.4.4 LSO Team Responsibilities

Demonstrate an awareness of the responsibilities of each LSO platform team member during a recovery.

3.4.4A LSO Scan Breakdown

LSO scan breakdown (GS, LU, AOA cues) can lead to drastic deviation in one dimension. For example, a common LSO (and pilot) mistake is excess attention to GS at the expense of LU. Thus the B/U LSO must also be actively involved in the pass and alert to breakdown of controlling LSO scan.

VAR: profiles
responses

REQ: 1.1, 1.2, 1.3

RELATED: 1.0A

3.4.4B Monitor of Job Aids

LSO (or B/U, or other team member) must always check roll angle, hook-to-ramp, hook-to-eye and wind before each pass.

VAR: roll angle
hook-to-ramp
hook-to-eye
wind direction/velocity
CLASS

REQ: 2.5.4

3.4.4C Monitor of Radio

At least one LSO must always be monitoring the radio during a recovery.

VAR: radio transmissions requiring LSO attention

REQ: 2.5.4

3.4.4D Backup LSO

The B/U LSO should never assume that the controlling LSO will keep aircraft off the ramp or that the controlling LSO has a handle on a lineup deviation. Be prepared (as B/U LSO) to give waveoff.

VAR: profiles requiring waveoff

REQ: 2.4

RELATED: 4.4E

3.4.4E Controlling LSO

As controlling LSO, do not become too dependent on aircraft control inputs from B/U LSO.

VAR: B/U LSO calls
profiles

REQ: 2.0

4.0 RECOVERY MANAGEMENT

This instructional area is primarily concerned with LSO decision skills associated with the overall recovery process, as opposed to individual approaches. The intent of this block is to enable the trainee to effectively advise and interact with others in the overall recovery process and wave approaches under stressful conditions.

4.1 Landing Geometry

4.1.1 Recommendations Regarding Landing Geometry

Initiate recommendations for adjustments to landing geometry and other manipulable recovery conditions.

4.1.1A High WOD

For WOD greater than 35 knots, a 4.0 degree basic angle should be used. When basic angle is changed, CATCC must be informed.

VAR: wind
basic angle
profiles

REQ: 3.3.3

RELATED: 4.3.2A

4.1.1B MOVLAS, Lens Stabilization

As a rule of thumb, if 50% or more of the passes are indicative that pilots are "chasing the ball", MOVLAS should be rigged. If stabilization appears good, stick with lens.

VAR: profiles
deck motion

REQ: 3.3.2, 3.4.1

4.1.1C High WOD

When the wind is 30-35 knots and aircraft are landing short, consideration should be given to targeting the number 4 wire.

VAR: wind
profiles

REQ: 3.3.3

4.1.1D Barricade Recovery

For a barricade recovery, check the ship's trim and make appropriate adjustments to targeted touchdown.

VAR: barricade
ship trim

REQ: 3.2

RELATED: 4.2.1C

4.1.1.1 Requirements For Landing Geometry Adjustments

Recognize the indications of requirements for adjustments to landing geometry and other manipulable recovery conditions.

4.1.1.1A Ship Trim

Use dynamic hook-to-ramp and/or CLASS indicator to help detect out-of-trim condition for ship and its effect on hook-to-ramp clearance and touchdown point.

VAR: ship trim
profiles

REQ: 2.0

4.1.1.1B Roll Angle Changes

Roll angle changes to move targeted touchdown point should be considered for missing wires and for excessive out-of-trim condition.

VAR: ship trim
wires available
roll angle
profiles

REQ: 2.0

4.1.1.1C Hook-to-Ramp Clearance

For normal recovery ops, on-glideslope hook-to-ramp clearance should never be less than 10 feet.

VAR: hook-to-ramp indicator
ship trim
profiles

REQ: 2.0

4.1.1.1D Hook-to-Ramp Clearance

For a barricade recovery, on-glideslope hook-to-ramp clearance should never be less than 8 feet.

VAR: barricade
ship trim
hook-to-ramp indicator
CLASS indicator

REQ: 2.0

RELATED: 4.2.1D

4.1.1.1ʟ Ship Trim

If during a recovery, there are a lot of relatively smooth bolters or early wires, it may be an indication that the ship is out of trim.

VAR: profiles
ship trim

REQ: 3.0

4.1.1.1F Ship Trim

Recommend a change in targeted touchdown point when an out-of-trim condition causes a change in touchdown point by about half the distance between wires. Also, when the 4 wire, or 4 and 3 wires are missing.

VAR: ship trim
wires available
CLASS indicator

REQ: 2.0

4.1.2 Waving With Adverse Landing Geometry Conditions

Demonstrate the ability to modify aircraft control strategies in response to adverse influences on landing geometry.

4.1.2A Roll Angle Change

When late wire(s) is missing and roll angle has been changed, do not forget that hook-to-ramp clearance has been reduced.

VAR: wires available
roll angle
profiles
CLASS indicator
hook-to-ramp indicator

REQ: 3.0

4.1.2B Ship Trim (Port List)

Avoid allowing a R-L drift particularly when ship has port list.

VAR: profiles
ship trim
hook-to-ramp indicator
CLASS indicator

REQ: 2.2, 2.4

4.1.2C Ship Trim (Starboard List)

Avoid allowing a L-R drift particularly when ship has a starboard list.

VAR: profiles
ship trim
hook-to-ramp indicator
CLASS indicator

REQ: 2.2, 2.4

4.1.2D Ramp Down Condition

With a ramp out-of-trim condition, touchdown angle is changed. Try to minimize excess sink rate landings for ramp <u>down</u> condition.

VAR: ship trim
profiles
hook-to-ramp indicator
CLASS indicator

REQ: 2.1, 2.4

4.1.3 Carrier Differences

Demonstrate an awareness of the general variations in landing geometry and recovery equipment among different aircraft carriers.

4.2 Malfunction/Emergency Situations

4.2.1 Critical Malfunctions/Emergencies - Recommendations

Initiate recommendations associated with the recovery of aircraft experiencing critical malfunctions/emergencies.

4.2.1A Abnormal Configuration

For abnormal configuration approaches always check to see if a roll angle change is needed.

VAR: aircraft type
aircraft configuration
roll angle

REQ: 3.2

4.2.1B F-4, WOD, Requirements

For F-4, with loss of BLC or half-flap configuration, approach speed is very high. Therefore WOD requirements are critical.

VAR: aircraft type
aircraft malfunction
aircraft configuration
wind
profiles
responses

REQ: 3.2, 3.3.3

RELATED: 4.2.2N

4.2.1C Barricade Recovery, Ship Trim

For a barricade recovery, check the ship's trim and make appropriate adjustments to targeted touchdown.

VAR: barricade
ship trim
hook-to-ramp indicator
CLASS indicator

REQ: 3.2

RELATED: 4.1.1D

4.2.1D Barricade Recovery

For a barricade recovery, on-glideslope hook-to-ramp clearance should never be less than 8 feet.

VAR: barricade
ship trim
hook-to-ramp indicator
CLASS indicator

REQ: 2.0

RELATED: 4.1.1.1D

4.2.2 Critical Malfunctions/Emergencies - Waving Strategies

Demonstrate ability to modify aircraft control strategies in aircraft malfunction/emergency situations (except barricade).

4.2.2A Changes In Pilot Habit Patterns

Any malfunction which causes a change in the normal pilot habit patterns can degrade the visual portion of the approach (i.e. no TACAN, no needles, no gyro).

VAR: aircraft malfunction (pilot instruments)
ops factors (ship NAVAIDS, CCA)
profiles

REQ: 3.1, 3.2

RELATED: 4.3.1B

4.2.2B ACLS Mode I

Remain alert for malfunction during ACLS Mode I approach. Smooth trends early in approach are no assurance of successful termination.

VAR: approach mode
profiles
aircraft types

REQ: 2.0, 3.2

4.2.2C Single Engine Approach

For single engine approach, do not accept a poor start.

VAR: engine malfunction
profiles
aircraft type

REQ: 2.0, 3.2

4.2.2D Obtain Briefing On Malfunction

Whenever time permits, obtain briefing on aircraft malfunction. Try to avoid relying on memory.

VAR: aircraft malfunction

REQ: 3.2

4.2.2E Malfunctions and Speed Differences

Be aware of possible configuration and/or speed differences for an aircraft with a malfunction.

VAR: aircraft malfunction
aircraft configuration
speed indicators
wind

REQ: 2.5.4, 3.2, 3.4

4.2.2F Abnormal Configuration and Speed Differences

For a malfunction situation with abnormal configuration, always ask the pilot what his approach speed will be (in IAS).

VAR: aircraft malfunction
aircraft type
wind

REQ: 3.2

4.2.2G A-6, Hydraulic Failure

For A-6, flaps can creep up with hydraulic failure.

VAR: aircraft type
aircraft malfunction
profiles

REQ: 3.2

4.2.2H S-3, No Flap Approach

For S-3, no flap approach, waveoff point must be moved out significantly.

VAR: aircraft type
aircraft configuration
profiles
responses

REQ: 2.4, 3.2

4.2.2I F-14, Single Engine Approach

For F-14, pilot has to work very hard for a successful single engine approach.

VAR: aircraft type
engine malfunction
profiles
responses

REQ: 3.2

4.2.2J S-3 and E-2, Single Engine Approach

For S-3 and E-2, single engine approach, lineup control is difficult due to assymetric thrust.

VAR: aircraft type
engine malfunction
profiles
responses
wind

REQ: 3.2

4.2.2K E-2, Single Engine Approach

For E-2 on single engine approach, decel must be avoided.

VAR: aircraft type
engine malfunction
profiles
responses

REQ: 3.2

4.2.2L F-4, Single Engine Approach

On single engine approach, F-4 is underpowered and needs after-burner on waveoff and bolter.

VAR: aircraft type
engine malfunction
profiles
responses

REQ: 3.2

4.2.2M C-1, Single Engine Approach

For a single engine landing, the C-1 is faster and should not flare for landing.

VAR: aircraft type
engine malfunction
profiles

REQ: 3.2

4.2.2N F-4, WOD Requirements

For F-4, with loss of BLC or half-flap configuration, approach speed is very high. Therefore WOD requirements are critical.

VAR: aircraft type
aircraft malfunction
aircraft configuration
wind
profiles
responses

REQ: 3.2, 3.3.3

RELATED: 4.2.1B

4.2.3 Waving Strategies For Barricade Recovery

Demonstrate ability to modify aircraft control strategies for barricade recovery situations.

4.2.3A E-2, Lineup Criticality

For E-2, lineup is extremely critical ($\pm$ 2-1/2 feet) for a barricade recovery.

VAR: aircraft type
barricade
profiles
responses
wind

REQ: 3.1, 3.2

4.2.3B "Cut" Call

For barricade engagement, give "cut" call prior to engagement, but only after ramp is made.

VAR: barricade
profiles
aircraft types

REQ: 3.0

4.2.3C Pilot View of Meatball

For barricade recovery, remember that pilot's view of meatball will be lost temporarily in-close.

VAR: barricade
profiles
aircraft types

REQ: 3.0

4.2.3D Waveoff Point

For barricade recovery, waveoff point must be moved out significantly.

VAR: barricade
profiles
aircraft type
responses

REQ: 3.0

4.2.3E Hook-to-Ramp Clearance

For barricade recovery, remember that hook-to-ramp clearance is reduced and that basic angle is 4.0 degrees.

VAR: barricade
profiles
aircraft type
responses

REQ: 3.0

4.2.3F Hook-to-Ramp Clearance And Touchdown Point

For barricade recovery, remember that hook-to-ramp and hook touchdown point are different for each aircraft type.

VAR: barricade
profiles
aircraft type

REQ: 3.0

4.3 Operational Situations

4.3.1 Waving Under Pressure Conditions

Demonstrate capability to maintain high safety standards while controlling aircraft under heavy boarding pressure and ops tempo situations.

4.3.1A Never Compromise Safety

LSO has dual waving responsibilities (responsible for safe <u>and</u> expeditious recovery). The safety aspect must <u>never</u> be compromised.

VAR: pressure situations

REQ: 3.0

RELATED: 4.4A

4.3.1B Malfunctions, Pilot Habit Patterns

Any malfunction which causes a change in the normal pilot habit patterns can degrade the visual portion of the approach (i.e. no TACAN, no needles, no gyro).

VAR: aircraft malfunction (pilot instruments)
ops factors (ship NAVAIDS, CCA)
profiles

REQ: 3.1, 3.2

RELATED: 4.2.2A

4.3.1C CQ Operations

For CQ-type "endurexes", the last pass has a good probability of exhibiting some type of "get-aboard-itis".

VAR: profiles
responses

REQ: 3.1

4.3.1D CQ, Pilot Scan

During CQ, pilot scan is usually slow, therefore, be extremely cautious of multiple deviations in-the-middle to in-close.

VAR: profiles
response

REQ: 2.0, 3.1

RELATED: 3.1.1.1B

4.3.1E F-4 and EA-3B, Fuel Criticality

F-4 and EA-3B are very fuel critical due to max trap fuel limitations.

VAR: aircraft type
fuel state
divert field
profiles
responses

REQ: 3.1, 3.2

4.3.1F Low Fuel State

Do not let low fuel state situation or any other boarding pressure cause you to lessen the safety margin for an approach.

VAR: fuel state
profiles
other pressure factors

REQ: 3.0

4.3.1G Waveoff Decision Point

Never press the waveoff decision point, no matter what boarding pressure exists.

VAR: pressure factors
profiles
responses

REQ: 3.0

4.3.1H *Getting An Aircraft Aboard*

For a situation requiring increased need for a trap, give extra aid to pilot earlier than usual in an approach. Work to get aircraft in a "workable" position in close (i.e. more informative calls early).

VAR: profiles
pressure factors
responses

REQ: 3.0

4.3.1I Use Of "Go For It" Calls

Do not use calls that can be misinterpreted by the pilot as "go for it" until the ramp is made, no matter what the pressure to get the aircraft aboard.

VAR: pressure factors
profiles
responses

REQ: 2.0

RELATED: 2.1A

4.3.2F Plane Guard Position, No Horizon

When there is no horizon and deck is moving, have plane guard destroyer or helo positioned aft of the ship near final bearing to aid in glideslope reference.

VAR: ambient light
deck motion
horizon reference
profiles

REQ: 3.3

RELATED: 3.3.2C, 3.3.4A

4.3.2G No Speed Indicator

If closure speed readout is not available on the platform, consider asking for speed calls from Air Boss or CATCC.

VAR: speed indicators
wind
aircraft malfunctions

REQ: 3.0

RELATED: 3.4.3A

4.4 LSO Team Duties, Responsibilities And Interactions

Demonstrate an awareness of the duties, responsibilities and interactions among all members of the LSO platform team during a recovery.

4.4A Safe And Expeditious Recovery

LSO (and LSO team) has dual waving responsibilities (responsible for safe and expeditious recovery). The safety aspect must never be compromised.

VAR: pressure situations

REQ: 3.0

RELATED: 4.3.1A

4.4B Approach Lights And Aircraft Configuration

Do not accept an aircraft without an approach light or with a flashing approach light. If possible, ask pilot to check gear or hook (as appropriate) well prior to ball call.

VAR: approach light variations
profiles
night
aircraft configurations
heavy ops tempo/close recovery intervals

REQ: 2.5.1

RELATED: 2.5.1A

4.4C Securing From Platform

Do not secure from the LSO platform with the lens still on.

VAR: ?

REQ: ?

4.4D Platform Readiness For Recovery

Do not let the lens be turned on until assured you have the capability to communicate and to use the pickle.

VAR: ?

REQ: ?

4.4E Backup LSO

The B/U LSO should never assume that the controlling LSO will keep aircraft off the ramp or that the controlling LSO has a handle on a lineup deviation. Be prepared (as B/U LSO) to give waveoff.

VAR: profiles requiring waveoff
heavy ops tempo
pressure situations

REQ: 2.4, 3.4

RELATED: 3.4.4D

4.4F Fatigued or Medically Grounded LSO

A fatigued or medically grounded LSO should not be waving or backing up.

VAR: ?

REQ: ?

4.4G Monitor of Closure Speed

LSO (or B/U) must continually check closure speed to insure adherence to max engaging speeds, especially under low WOD conditions.

VAR: speed indicators
wind
profiles
responses
pressure situations

REQ: 2.3, 2.4, 3.0

RELATED: 3.3.3I

4.4H High Workload Situations

In high workload situations involving MOVLAS, consider dividing the controlling LSO workload (one with MOVLAS, one with radio).

VAR: MOVLAS
pressure situations
deck motion
profiles
responses

REQ: 3.0

4.4I Platform Calls With Fouled Deck

Do not allow use of platform calls like "wire coming back" and "good chance". They could infuence the controlling LSO to press the waveoff point in a foul deck situation.

VAR: profiles
deck status
responses

REQ: 3.4

4.3.1J Starboard Side MOVLAS

With a starboard side MOVLAS, expect some breakdown in pilot scan.

VAR: MOVLAS
profiles
response

REQ: 3.1, 3.4.1

RELATED: 3.4.1F

4.3.2 Recovery Coordination

Demonstrate capability to effectively coordinate recovery activities with Air Department (PRIFLY) and Air Operations (CATCC) personnel.

4.3.2A Change Of Basic Angle

For WOD greater than 35 knots, a 4.0 degree basic angle should be used. When basic angle is changed, CATCC must be informed.

VAR: wind
basic angle
profiles

REQ: 3.3.3

RELATED: 4.1.1A

4.3.2B Recovery Rules And Limits

When supervisory personnel demonstrate confusion or incompetence, LSO must know the rules (i.e. max. engaging speeds, ramp "tap" to divert or barricade, crosswind limits, etc.) and be prepared to assert himself ("hang it out") to insure correct action is taken.

VAR: complex operational situations:
- aircraft emergencies
- deck motion
- wind
- pilot proficiency
- visibility
- CQ ops
- etc.

REQ: 3.0

4.3.2C CCA "Losing The Bubble"

When CCA "loses the bubble" on aircraft control, LSO must be prepared to safely salvage the situation.

VAR: profiles
CCA control

REQ: 3.0

4.3.2D Aborting The Recovery Process With Pickle

When directed to wave under obviously unsatisfactory recovery conditions (i.e. insufficient WOD, excessive crosswind, etc.), the pickle can be a very effective tool for aborting the recovery process.

VAR: wind
deck motion
low fuel state
aircraft emergencies
pilot proficiency
visibility

REQ: 3.0

4.3.2E SPN-42 Glideslope Calibration

CATCC voice calls may indicate that the SPN-42 glideslope is improperly calibrated. Inform them if such is the case.

VAR: CCA calls
SPN 42 glideslope indicator
profiles

REQ: 1.0, 2.5.4

C-II PRELIMINARY LSO SYLLABUS

A preliminary LSO syllabus sequence is delineated below. An outline is presented in terms of codes from the LSO Training Requirements Data Base (Appendix C, Section I) and topical descriptions for groupings of training requirements. The syllabus is organized sequentially into four major levels:

I Basic Waving Skills (Table C-I)

II Waving Pilot and Aircraft Variations (Table C-II)

III Complex Waving Situations (Table C-III)

IV Critical Waving Situations (Table C-IV)

Level I includes the training requirements from the Perception (1.0) and Basic Aircraft Control (2.0) blocks of the data base with the addition of night waving conditions (3.3.1). Level II includes Pilot Characteristics (3.1), Aircraft Characteristics (3.2), and LSO Station (3.4) training requirements. Level III includes training requirements for most of the Environmental Conditions (3.3) plus Landing Geometry (4.1) and LSO Team (4.4). Level IV includes training requirements for Malfunctions/Emergencies (4.2), Reduced Visibility (3.3.5) and Operational Pressure Situations (4.3).

This syllabus presents a recommended sequence in which the training requirements should be addressed. It does not combine or separate training requirements into lessons or session. Also, it does not indicate the medium (or media) recommended to address each requirement. Additional attention will be required from course-design and SME personnel to translate this syllabus sequence into a detailed course of instruction, be it in conjunction with the existing training resources or with an LSO Training System.

ORGANIZATION AND SEQUENCING CONSIDERATIONS

Several factors were considered in the organization and sequencing of training requirements for the prelliminary LSO syllabus. They are discussed below:

PREREQUISITES. The trainee must have acquired (or at least have been exposed to) some skill (or knowledge) prior to attempting to acquire others. An example would be a requisite for the skill to wave an F-14 prior to introducing a single engine approach. Another example would be a

TABLE C-II-1 LEVEL I BASIC WAVING SKILLS

Topic	Code
Glideslope Perception	1.1 1.1.1 1.1.2
Lineup Perception	1.2 1.2.1 1.2.2
AOA Perception	1.3 1.3.1 1.3.2
Range	1.4
Deviation Corrections	1.1.3 1.2.3 1.3.3
Perceptual Scan	1.0A
Waveoff	2.4 2.4A 2.4B 2.4.1 2.4.1B 2.4.1C 2.4.1D 2.4.1E 2.4.1A
Voice Call Strategy	2.0A
Glideslope Control	2.1.1 2.1.1A 2.1 2.1A
Lineup Control	2.2.1 2.2
AOA Control	2.3.1 2.3

(Continued)

TABLE C-II-1 (Continued)

Topic	Code
Platform Scan	2.5.4 2.4.1F 2.5.4A
LSO Talkdown	2.5.5
Configuration	1.6
Closure Speed	1.5
Other Control and Advisory Requirements	2.5 2.5.2 2.5.2A 2.5.2B 2.5.1 2.5.1A 2.5.3
Grading Approaches	1.7.1 1.7.2 1.7A 1.7
Waving Dusk and Night Conditions	3.3.1

TABLE C-II-2. LEVEL II WAVING PILOT AND AIRCRAFT VARIATIONS

Topic	Code
Approach Profiles	3.1.1
Recognizing Approach Trends	3.1.1.1.1 3.1.1.1.1E 3.1.1.1.1B 3.1.1.1.1C 3.1.1.1.1A 3.1.1.1.1D
Waving Common Approach Profiles	3.1.1.1 3.1.1.1C 3.1.1.1D 3.1.1.1E 3.1.1.1A 3.1.1.1B
Recognizing Pilot Response Variations	3.1.2.1 3.1.2.1B 3.1.2.1A
Waving Pilot Response Variations	3.1.2 3.1.2A 3.1.2C 3.1.2D 3.1.2B
Recognizing Critical Outcome Profiles	3.1.1.2.1 3.1.1.2.1A 3.1.1.2.1C 3.1.1.2.1B
Waving Critical Outcome Profiles	3.1.1.2
General Aircraft Differences	3.2.1
Aircraft Visual/Audio Characteristics	3.2.6 3.2.6A 3.2.6B
General Aircraft Waving Strategies	3.2.5 3.2.5A 3.2.5B

(Continued)

TABLE C-II-2 (Continued)

Topic	Code
LSO Station	3.4
Abnormal Communications	3.4.2 3.4.2B 3.4.2A 3.4.2C
MOVLAS	3.4.1 3.4.1A 3.4.1B 3.4.1D 3.4.1C 3.4.1E 3.4.1F
LSO Platform Duties	3.4.4 3.4.4B 3.4.4C 3.4.4D 3.4.4E 3.4.4A
LSO Job Aid Malfunctions	3.4.3 3.4.3A

TABLE C-II-3. LEVEL III COMPLEX WAVING SITUATIONS

Topic	Code
Environmental Conditions	3.3
Horizon Reference	3.3.4
	3.3.4C
	3.3.4B
	3.3.4A
Deck Motion	3.3.2
	3.3.2B
	3.3.2B
	3.3.2F
	3.3.2H
	3.3.2G
	3.3.2E
	3.3.2C
	3.3.2B
Wind Over Deck	3.3.3
	3.3.3J
	3.3.3D
	3.3.3E
	3.3.3F
	3.3.3G
	3.3.3H
	3.3.3A
	3.3.3I
	3.3.3B
	3.3.3C
Landing Geometry	4.1
Recognizing Adverse Landing Geometry	4.1.1.1
	4.1.1.1C
	4.1.1.1D
	4.1.1.1B
	4.1.1.1A
	4.1.1.1F
	4.1.1.1E

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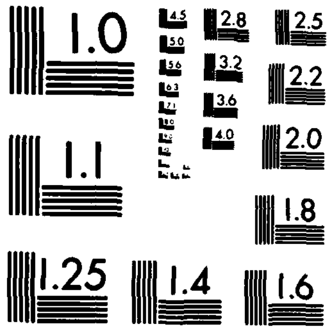

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE C-II-3 (Continued)

Topic	Code
Recommendations to Optimize Landing Geometry	4.1.1 4.1.1A 4.1.1C 4.1.1B 4.1.1D
Waving With Adverse Landing Geometry	4.1.2 4.1.2A 4.1.2D 4.1.2B 4.1.2C
LSO Team Responsibilities and Interactions	4.4 4.4A 4.4B 4.4I 4.4G 4.4E 4.4H 4.4C 4.4D 4.4F

TABLE C-II-4. LEVEL IV CRITICAL WAVING SITUATIONS

Topic	Code
Malfunctions/Emergencies	4.2
Barricade Recovery	4.2.3
	4.2.3D
	4.2.3E
	4.2.3C
	4.2.3B
	4.2.3F
	4.2.3A
Recommendations for Malfunction/Emergencies	4.2.1
	4.2.1A
	4.2.1B
	4.2.1D
	4.2.1C
Waving Malfunctions/Emergencies	4.2.2
	4.2.2D
	4.2.2A
	4.2.2E
	4.2.2F
	4.2.2B
	4.2.2M
	4.2.2C
	4.2.2H
	4.2.2J
	4.2.2K
	4.2.2I
	4.2.2L
	4.2.2N
	4.2.2G
Reduced Visibility	3.3.5
	3.3.5C
	3.3.5B
	3.3.5A

(Continued)

TABLE C-II-4 (Continued)

Topic	Code
Operational Pressure Situations	4.3.1
	4.3.1H
	4.3.1I
	4.3.1J
	4.3.1B
	4.3.1D
	4.3.1C
	4.3.1G
	4.3.1F
	4.3.1A
Recovery Coordination	4.3.2
	4.3.2A
	4.3.2E
	4.3.2F
	4.3.2G
	4.3.2C
	4.3.2B
	4.3.2D
Carrier Differences	4.1.3

requirement for basic waving skills (under sterile to moderate recovery conditions) prior to the introduction of significant degradations in environmental conditions (i.e., pitching deck, low visibility).

Throughout the training, even relatively early in the program, the trainee must be exposed to variability of approach conditions; i.e., occasional deck motion (mild to moderate), WOD variations (moderate but well within recovery criteria), pilot deviations (profiles), pilot responses, late (moderately) clear deck indications, etc. This would keep the trainee from becoming too accustomed to "sterile" recovery conditions (which seldom exist on the job) and help ease him into the more complex aspects of waving. Thus the syllabus will need a sequencing scheme for these "background variables," as well as a separate scheme for the "primary instructional variables." Only the latter are covered in this preliminary syllabus. Development of an efficient schedule for the background variables might be accomplished best when the system is in the first stages of use.

DIFFICULTY. The training situations should be sequenced so that they are progressively more difficult throughout the syllabus. The level of difficulty is controlled by the introduction of situation variables and differing values of these variables. Progressive difficulty will be reflected both throughout the syllabus and within individual blocks of the syllabus. For example, throughout the syllabus the combinations of variables will be manipulated to provide increasing difficulty. Whereas, within a block of training, the difficulty level based on situation variables will be minimal initially. Later in the block difficulty will be increased. Difficulty can become an adaptive variable, dependent on the trainee's level of success, as discussed in Appendix A.

LSO QUALIFICATION LEVELS. The criteria for LSO qualification levels is another factor that influenced the establishment of this sequence of training requirements. Qualification levels used included those officially established by LSO NATOPS as well as some others which are informally applied by supervisory LSOs during OJT.

TASK CRITICALITY. Some aspects of waving have critical implications for safety. These should be presented early in the training program to provide more opportunities for practice in order to enhance skill retention. Typically, some of the more critical tasks are also the more difficult and, thus, are often relegated to the latter, more advanced, stages of the program. This will be avoided when possible.

CRITICAL BUT INFREQUENT TASKS. Some critical LSO skills are exercised very infrequently in the operational environment. An excellent example of a critical but infrequent task is the barricade recovery. It is also a task that cannot be practiced in the operational environment. A training system is an ideal setting for emphasis on such tasks they must be presented early enough to provide extensive practice opportunities.

APPENDIX D

SUPPLEMENTARY INFORMATION ON TRAINING IMPLICATIONS OF THE LSO TASK

SECTION D - TRAINING IMPLICATIONS OF THE LSO TASK

The LSO training system features and functions stem directly from the combination of LSO training requirements and current training technology. This structure is shown in Figure D-1.

In this Appendix, LSO training issues will be discussed, followed by a listing of the variables that affect the task. Finally, these will be integrated into the projected general functions required of an automated LSO training system (LSOTS).

OVERVIEW OF THE LSO TASK

The LSO's task is at once demanding, difficult, dangerous and important. The Naval Aviator is a highly select breed and only a few Naval Aviators go on to become LSOs. The LSO is tasked with the responsibility for training pilots in carrier landing procedures and for conducting the recovery of aircraft aboard the ship, as well as for training new LSOs. Therefore, the overall view of the LSO task is three fold: pilot training; carrier landing recovery operations; and LSO training.

As mentioned earlier in this report, the present conception of the LSOTS is to limit its *training function* to that of carrier recovery operations. The training functions of the LSO, both for pilot training and LSO training, will not be included in the design of the LSOTS because they emphasize the acquisition of instructional techniques rather than real-time interaction with simulated environmental events. Assuming, however, that the LSOTS is successful in training waving skills, it will also benefit the other aspects of the LSO's job.

The LSO's role in carrier landing operations, according to LSO NATOPS, is to conduct those operations in a "safe and expeditious" manner. The potential conflict of these two terms has been discussed in previous reports (Borden, 1969; McCauley and Borden, in press). An overview of the tasks in which the LSO engages in order to effect a safe and expeditious aircraft recovery will be given as an introduction to the functions that must be included in the LSO training system.

One task unit for the LSO is an aircraft recovery, which consists usually of about 18 to 25 aircraft. These planes are launched to accomplish some mission and when they return from the mission it is the task of the LSOs to safely recover these aircraft aboard the carrier. A team of four LSOs generally is assigned for each recovery. The team leader will designate one to act as Controlling LSO, while others act as Back-up and Book Writer. The Controlling LSO has the direct responsibility for aircraft control, and his task will be the focus for the LSOTS.

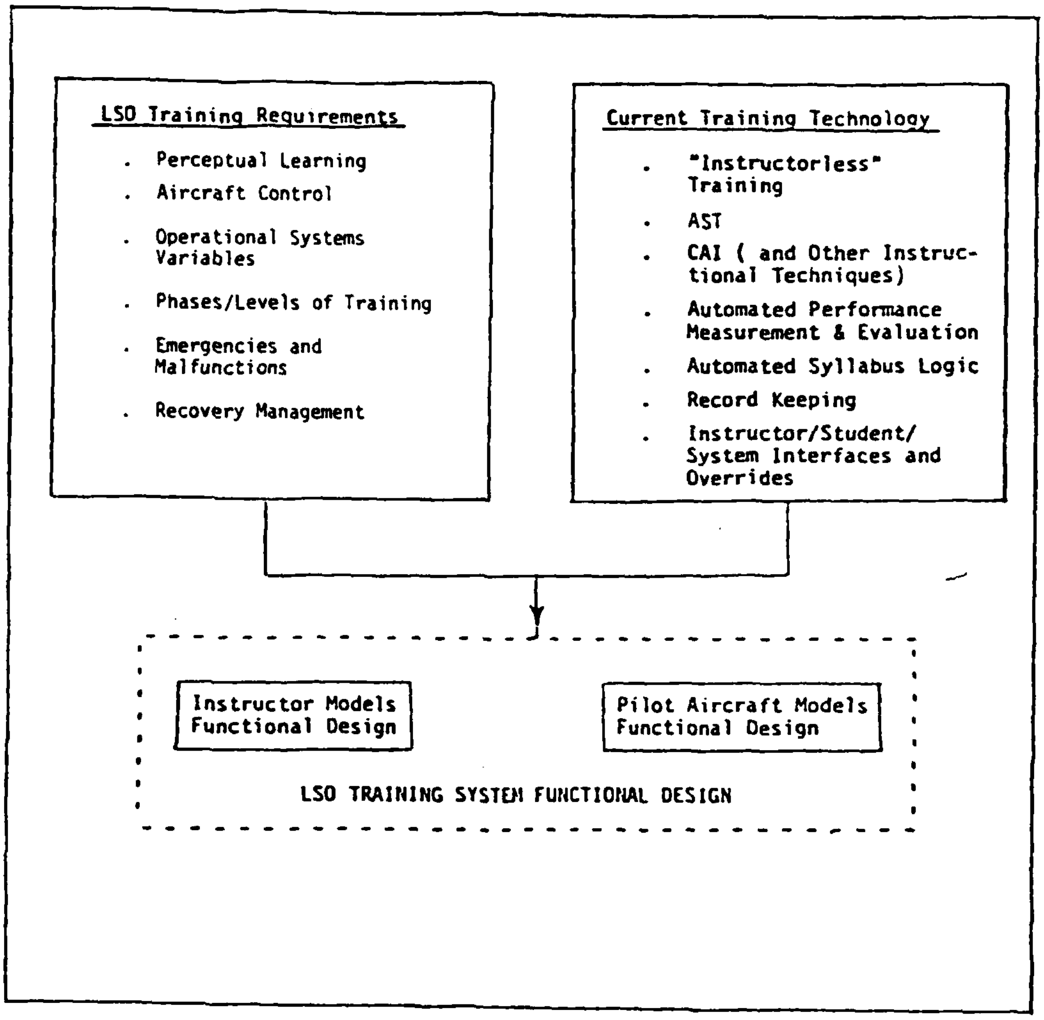

Figure D-1. The Central Role of AST in an Automated LSO Training System

The LSO's first task, before the recovery begins, is to check the status and operability of all equipment involved in the recovery. Of particular note are the Fresnel Lense Optical Landing System (FLOLS) and the equipment located at the LSO platform. When the recovery begins, the LSO's task consists of controlling the aircraft during the final approach to the carrier landing, usually a distance of approximately three quarters of a mile. During that three quarters of a mile, (about 30 seconds) the ultimate LSO task occurs, imposing an extremely high cogitive processing load. His output, however, may not be high. For example, the LSO may be intently monitoring the aircraft dynamics during the final approach, noting and predicting any deviations from optimum glidepath, line up, and angle of attack (AOA),and giving the pilot status information, corrective advice or mandatory maneuvers when necessary. In the case of an acceptable approach where no large deviation occurs, the LSO may never say or "do" anything. No radio transmission will be given to the pilot. This causes some difficulty for a performance measurement system. A high degree of skill and concentrated effort is going into the LSO's monitoring task but no performance output is occurring.

After the arrested landing, the LSO gives a grade to the pilot for the approach. In addition to the grade, he gives a description of the approach in what is called LSO shorthand. The grade and description are given verbally to an assistant LSO who is "writing book." The grade and description go into the LSO log book and are used subsequently when the LSO debriefs the pilot. After giving the grade and approach description the LSO prepares for the next aircraft ready for final approach. He may check certain equipment for information such as wind over the deck (WOD), lens roll angle, deck status, etc. The next aircraft may be ready for LSO control immediately after the last one landed, but on the average, the LSO will have about 30-60 seconds before acquiring control of the next aircraft.

One of the most critical aspects of the LSO's job is the waveoff. When an aircraft exceeds the limits of a safe approach, in the LSO's judgement, it will be waved off by the LSO. Another case in which a waveoff is given is when the carrier deck is "foul." That is, when an aircraft, person or any object is in the landing or roll-out area of the deck. The LSO is informed of the deck's status, clear or foul, by a light which indicates red or green. The light is in the LSO's field of view some distance aft of the LSO platform on the carrier deck. The waveoff command by the LSO is the final judgement about the acceptability of the approach. It is his best weapon for preventing landing accidents. It is a difficult, multivariate, predictive decision with expensive consequences. It requires a great deal of training.

To summarize the LSO's task during a carrier recovery, he engages in the following sequence of activities in the normal case: equipment checks; aircraft control (voice calls and waveoff) during final approach; grading and describing the approach at its conclusion; and monitoring equipment for information pertinent to the next approach.

In addition to these tasks another set of tasks at a slightly higher organizational level is conducted continuously by the skilled LSO. This set of tasks was called "recovery management" by the LSO Training Model Manager. Examples of this category of LSO task are items such as a series of approaches that result in landing outcomes different than expected by the LSO. For example, several successive aircraft may have been on glide slope in the LSO's view, but they "caught" a four wire rather than the targeted three wire. The LSO may then suspect that something is amiss in the landing geometry, the lens roll angle, the ships trim, etc. In other words, the LSO has the responsibility not only for controlling each approach, but the responsibility for managing the entire recovery process. He has at his disposal, therefore, certain actions that can be taken when a series of approaches does not seem correct or when deteriotating weather or environmental conditions warrant. Examples of these actions include changing the nominal lens roll angle, rigging the MOLVAS when environmental conditions have led to a pitching deck that exceeds the motion compensation of the lens, or even calling the air boss to recommend the cessation of air operations entirely.

In terms of training system design and development, the most demanding aspect of the LSO task is its real-time interaction. The LSO is in constant communication with the pilot during the final 30 seconds of the approach and expects immediate response from the pilot to any LSO requests, particularly the imperative LSO calls such as "Power." The LSO's task places other demands on LSOTS design including the fidelity of simulation required by the extreme sensitivity of the LSO perceptual skills. Very slight changes in aircraft attitude for example, may be perceived and acted on by the LSO. Therefore, simulation of the LSO's visual environment, particularly the approaching aircraft, has a requirement for a high degree of fidelity to enable perception of small changes in aircraft position and orientation. Other difficulties in LSOTS design are not a result of the LSOs task, but of the automated technologies to be included, such as speech recognition and automated performance measurement. These issues were discussed in Appendix A.

The LSOTS is directed toward fleet carrier operations. Simulation of that operational environment, therefore, is an important part of the training system design. Use of the training system, however, will not be restricted to Phase III* of LSO training - "carrier training." The environmental/operational simulation and the instructional features of the training system will be capable of supporting all phases of LSO training, from initial "eye calibration" to advanced "refresher" training for an already highly qualified LSO.

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*LSO NATOPS defines the three phases of LSO training as Phase I, Basic Instruction; Phase II, FCLP Training, and Phase III, Carrier Training.

The LSO training system will have an "instructorless" capability to conduct LSO training without the requirement for an instructor LSO to be present. Similarly, the LSOTS will have the capability to function without the requirement for a pilot to fly the simulated approach and respond to the LSO trainee's communications. These "top level" requirements of the LSOTS have a major impact on the design of the system. The "instructorless" requirement results in the need for a well-designed automated instructor. The "pilotless" requirement results in the need for a well-designed automated pilot/aircraft (Hooks and McMurray, in press). The instructorless and pilotless capabilities of the LSOTS appear to be feasible only with an accurate, real-time automated speech recognition system.

LSO TASK TAXONOMY

A candidate taxonomy of the LSO task was developed, with emphasis on skill acquisition and training. This exposition of a task structure was considered important because LSOTS functions in general (and automated instructor model functions in particular) will be derived, in part, from a conception of the LSO task structure and from assumptions about the acquisition of this structure by a trainee.

A preliminary listing of stages of LSO training is given in Table D-1. The LSO task is very complex (see McCauley and Borden, in press), and analysis of the task into finite stages is somewhat arbitrary. Nevertheless, the listing reflects previous LSO literature review and discussion with the LSO Training Model Manager. This listing occurred before the development of the information contained in Appendix C of this report. If any conflict exists, Appendix C should be given priority. This listing occurred before the development of the information contained in Appendix C of this report. If any conflict exists, Appendix C should be given priority.

To support all levels of training an LSOTS must have the capability to deal with all of the important variables affecting the LSO task. Some of the major benefits of the LSOTS may be expected from the advanced training involving various aircraft types and critical, low frequency events such as barricade arrestment or MOVLAS with pitching deck on a dark night with no horizon. More detailed description of variables that affect the LSO's task will be given later in this appendix. The task taxonomy presented in Table D-1 is intended only to demonstrate the broad range of conditions and responsibilities that require such an extended training time to develop a fully qualified and highly skilled LSO. The information in Appendix C supercedes this list.

An automated instructor model for LSOTS must be capable of specifying an appropriate set of variables and conditions in support of each stage of LSO training. Moreover, the simulation of all of these variables must be inherent in the design of the system.

TABLE D-1 . PRELIMINARY TAXONOMY OF LSO TASK REQUIREMENTS IN AIRCRAFT CONTROL

- RESPONSIBILITIES, DUTIES AND OBJECTIVES OF THE LSO

  Knowledge of his purpose.

- PUBLICATIONS, EQUIPMENTS, LANDING SYSTEMS

  Knowledge of supporting documentation, LSO equipments, ship's landing aids, landing geometry, etc.

- PERCEPTION

  Perceptual learning of nominal glideslope and line-up. Perceptual learning of deviations from nominal.

- TERMINOLOGY ACQUISITION (WRITING BOOK)

  Learning the LSO terminology for description of approach, LSO shorthand, and basic LSO voice calls.

- RECALL OF APPROACH

  Post-approach description in LSO terminology (based on memory reconstruction of pass).

- EYE-MOUTH COORDINATION

  Giving basic LSO voice calls in response to approach deviations.

- WAVE-OFF

  Judging the minimum wave-off point. Learning the wave-off envelope (for one aircraft).

- PREDICTION

  Advanced perceptual learning of impending deviations in aircraft approach parameters.

- AIRCRAFT CONTROL STRATEGIES

  Acquiring and enveloping strategies for controlling aircraft.

(Cont.)

TABLE D-1. (Continued)

o MOVLAS

Conducting a MOLVAS approach in stable and pitching deck conditions.

o AIRCRAFT TYPES

Applying skills to all types of carrier aircraft.

o AIRCRAFT EMERGENCIES AND MALFUNCTIONS

Knowledge of recommended procedures and appropriate LSO actions during an aircraft emergency or equipment malfunction.

o LSO TALKDOWN

When and how to give an LSO talkdown approach.

o RECOVERY MANAGEMENT

Awareness and control of all variables affecting a recovery, such as malfunction of equipments, MOVLAS, pitching deck, no horizon, barricade arrestment, bingo procedures, change targeted wire, ship's trim, CATCC errors, high wind, max engaging speed, etc.

LSOTS FUNCTIONAL DESCRIPTION

The purpose of the LSOTS is to facilitate training. It is intended to supplement and support normal LSO training. Elimination of the OJT necessary for LSO qualifications is <u>not</u> the purpose of the LSOTS. With proper design and use, the LSOTS will enhance the trainees' acquisition of the concepts and knowledge necessary for the LSO job and it will enhance his readiness to assimilate FCLP and ship-board training.

The LSOTS will have the capability to interact with the LSO trainee who has not used the system previously, create appropriate records and files for the trainee, query the trainee about previous LSO experience and qualification levels, conduct familiarity exercises and demonstrations as needed, estimate the proper syllabus entry point for the trainee, generate voice data collection, and conduct a training session. In conducting a training session, the LSOTS will have the capability to: brief the trainee and instructor on the objectives of the session and the past performance of the trainee; provide teaching and instruction about the concepts or skills to be learned; select and initiate appropriate task scenarios and practice problems; simulate the environmental and operational cues necessary for training; drive the pilot/aircraft simulation as appropriate to LSO communications and simulated environmental events; assess and evaluate the trainee's performance; provide performance feedback to the trainee; adjust syllabus progress and problem difficulty as a function of the trainee's performance; provide remedial instruction and practice when necessary; maintain records of the trainee's performance during the session; debrief the trainee and instructor at the end of a session; and recommend reading or other instructional materials in preparation for the next session.

In search of user acceptance from the LSO community, the LSOTS must be "realistic" in terms of event scenarios and pilot/aircraft/LSO interactions. Deviations in aircraft approach parameters must be perceptible to the LSO trainee at approximately the same magnitudes as in "real life", and the pilot/aircraft response to LSO calls and waveoffs must be simulated accurately. The time lags and magnitudes of the pilot/aircraft responses must appear "normal" to the experienced LSO.

INSTRUCTOR'S ROLE IN LSOTS

It has been stated that the LSOTS will be designed to be capable of "instructorless" training. What, then, will be the role of an LSO instructor? And how does that role affect the design of the automated instructor model?

The LSOTS will be designed to be capable of "instructorless" training, but full provision will be included for instructor involvement, at his discretion. The design goal of instructorless training throughout the syllabus ensures that training can be conducted even though no LSO instructor is available for a particular session. The additional capability for direct instructor invovlement in all aspects of the training program is required because the LSO instructor is responsible for proper training. Therefore, he should have available at all times complete information about the status and progress of each trainee. Override functions will permit the instructor to branch to any part of the curriculum, or to generate any set of conditions for an approach or a recovery scenario. Additionally, the instructor will have the capability to select instructional aids such as freeze, playback, display of any aircraft parameters, pilot's view, etc. He will serve as the final authority and manager of the training process. He will be essential to overcome unique or difficult problems in training. In summary, the instructor will be able to operate the entire system manually, usurping the functions of the automated instructor model. The system will maintain a record of instructor overrides, generating a data base for assisting in the upgrading and revision of the instructor model design.

The role of the instructor in the LSOTS ultimately will depend a great deal on the quality of the instructorless training. Iterative refinement of the automated instructor model should result in an optimized training program. To the extent that the instructor model or other subsystems do not function properly, the LSO instructor will be forced to take a more active role (see McCauley and Semple, 1980). Even with an optimized system, the LSO instructor should be available on a regular basis for answering questions, solving unique problems, and providing support to the trainee (Joplin, 1980).

The LSO instructor's role will be expected to vary with the trainee's position in the syllabus. At the beginning of training, trainees are likely to have many questions about the automated training system as well as LSO techniques and procedures. As the trainee progresses in the syllabus, he will become proficient at using the system (speech recognition, in particular, is likely to improve) and the instructor's role could be reduced.

The accuracy of the automated performance measurement and evaluation system will affect the instructor's role (Joplin, 1980; McCauley and Semple, 1980). If the system is accurate, the instructor's role can successfully be reduced. Rapid, accurate performance feedback is essential for nearly all types of learning. Difficulties in the design or implementation of the meausrement system (or the speech recognition system that feeds it) would necessitate the LSO instructor to be available for performance assessment and feedback.

The instructor workload is very heavy in the LSO Reverse Display (Hooks and McCauley, 1980). He must manually initialize the approach conditions, monitor and evaluate the trainee's performance, give feedback to the trainee about his performance (possibly using the replay feature), then decide what to present on the next approach. In addition, he may be communicating with the NCLT pilot in an attempt to obtain certain approach deviations. This type of "fully burdened" instructor role in the LSO Reverse Display may be partially responsible for its lack of use (except by the Phase I School). Automating these functions in the LSOTS should be a real advantage in reducing the already burdensome workload of the typical LSO. This is a worthwhile objective of the LSOTS, but reduction of the instructor's workload will be achieved only through the difficult task of obtaining near flawless performance of the many subsystems involved. The time required for full system development becomes another factor in the role of the instructor. He must play a more active role in early (prototype) versions of the system.

LSO TASK SIMULATION REQUIREMENTS

The LSO's waving task involves a large number of variables. A preliminary listing of the major variables by category is given in Table D-2. Each of these variables represents a potential feature to be included in the design of the LSOTS.

This listing includes the vast majority of variables that affect the LSOs task, but it is not exhaustive. The list was compiled from discussions with the LSO Phase I School personnel and from previous technical reports (Borden, 1970; Hooks, et al., 1978; McCauley and Hooks, 1980; McCauley and Borden in press).

All of these variables have implications for either the design or the use of an LSOTS. This preliminary identification of the major variables affecting the LSO task will enable subsequent work (in this project and others) to define the ranges of values of the variables, and to specify the value (or state, if it is a categorical variable) for the various scenarios that can be compiled into a training syllabus.

One conception of the variables affecting the LSO task is that they cover a broad range of frequency of occurrence. For example, aircraft deviations from glideslope would be a high frequency variable. Several deviations usually occur on each approach. Deck status (clear or foul deck) is less frequent, occurring approximately once per approach. Weather and visibility variables normally would be constant during a recovery period (about 20 approaches). Variables with very low frequency changes are exemplified by type of operations and flush-deck/recessed LSO platform.

The question of how to merge these variables into a cohesive training program must be addressed in courseware development. The data base provided in Appendix C is a first step toward formalizing this process. All of the listed variables have implications for LSO training and must be dealt with somewhere in the training curriculum. Some of them require hardware or software implementation for the simulation itself. For example, the variable "aircraft type" will require special

TABLE D-2. PRELIMINARY LISTING OF LSO TASK VARIABLES TO BE INCLUDED IN THE LSOTS

ENVIRONMENTAL

Wind	- direction, velocity, variability (both direction and velocity), burble
All Weather	- visibility, ceiling, cloud formations, precipitation, sea state, horizon
Day/Night	- ambient light, sun, moon, stars, sunset, sunrise
Background Noise	- ambient noise on carrier deck
Deck Motion	- Pitch, Heave, Roll, Dutch Roll, Periodicity, Consistency

PILOT (see Hooks and McMurray, in press)

Total carrier experience

Experience in-type

Recent carrier experience

Overcontrol/undercontrol or other tendencies or trends

Deck Spotter

Flies toward lens (moth syndrome)

Flies high ball

Overall proficiency

Responsiveness to LSO calls (time and magnitude)

Responsiveness to waveoff

Responsiveness to MOVLAS

Vertigo

(Cont.)

TABLE D-2. (Continued)

AIRCRAFT

- Type: A-6, A-7, E-2, EA-6B, F-4, F-14, F/A-18, S-3, C-2, VTX
- Configuration
  - Gear
  - Flaps (full or partial down)
  - Hook
  - Speed Brakes
  - Tow link/launch bar up
  - Nose gear not cocked (A-6)
- Engine Response Charateristics (by aircraft type)
- Lighting
  - Wing Tip
  - Approach Lights
  - Flashing AoA
  - F-14, Glove Vane Lights
  - A-6, PYLON Lights
  - S-3, DLC Light, anti-collision light
- DLC
- APC
- ACLS
- Malfunctions and Emergencies

(Cont.)

TABLE D-2. (Continued)

AIRCRAFT APPROACH DYNAMICS (see Hooks and McMurray, in press; McCauley and Borden, in press)

- Range
- Position (relative to glide slope and line-up)
    - High/Low
    - Left/Right
- Rate of Change of Position
    - High/Low Rate of Descent
    - Left/Right Drift
    - Closure Rate (airspeed-wind-carrier speed)
- Orientation
    - Pitch
    - Roll
    - Yaw
- Angle of Attack
- Power
    - Underpowered
    - Overpowered
- Sequences of Deviations (Approach Profile)

LANDING GEOMETRY

- Targeted Hook-to-Ramp Distance
- Targeted Hook Touchdown Point
- Hook-to-Eye Distance (by Aircraft Type)
- Nominal Glide Slope Angle (3 1/2 or 4°)

(Cont.)

TABLE D-2. (Continued)

LSO EQUIPMENT
- LSO Display Console
  - WOD Indicator
  - Hook to Ramp Indicator
  - PLAT
  - FLOLS Indicators
  - SPN-42 Radar Indicators
  - SPN-44 Radar Indicators
  - MOVLAS Position Indicator
  - Waveoff Indicator
  - ACLS unlock indicator
- LSO Head Up Display (HUD)
- Communications/Radio Controls and Headset
- Pickle Control (Wave off trigger and cut-light button)
- MOVLAS control

CARRIER
- Carrier class
- LSO Platform - flush deck or recessed deck
- Deck Distances
  - Ramp to #1 wire
  - Ramp to touchdown (#3 wire, centerline)
  - Ramp to LSO platform
  - Centerline to LSO platform
  - Tartgeted Hook to Ramp

(Cont.)

TABLE D-2. (Contiued)

Landing Area Width
Ship's Trim
Wake
Pendants Removed
Landing Aids (ship's recovery equipment)
FLOLS
MOVLAS
Deck Lighting
Clear/Foul Deck Light
ACLS
Arresting Gear
Barricade
NEW TECHNOLOGY
LSO HUD
CLASS
FLOLS Command Bars
OPERATIONAL
Zip Lip or EMCON
Ships turn
Ships course
Plane guard destroyer or helo
Type of operations (CQ, other)
Recovery Variables
Number of A/C

(Cont.)

TABLE D-2. (Continued)

Type of A/C
Tanker availability
Bingo Field availability
Bingo Fuel States
Pressure For Boarding
EMERGENCIES OR MALFUNCTIONS
Radio Failure (NORDO)
Aircraft Lighting Malfunctions
No flaps
No gear
No hook
Hook slap
Engine failure/malfunction
Accidents
Fly into water
Ramp strike
Hard landing
In-flight engagement
Others

software for each aircraft type, both for the proper visual display (from the LSO's perspective) and a supporting model of aircraft flight dynamics and performance characteristics.

The preliminary list of variables has direct implications for system design (hardware, simulation software, and training syllabus software). It helps to delimit and define the LSOTS with respect to the LSO's task. Other features and variables that must be defined are in the areas of the systemware necessary to accomplish real-time interaction, instructor aiding, performance assessment and diagnosis, and syllabus control.

LSO TRAINING PHILOSOPHY AND NEW PERFORMANCE MEASURES. In reviewing information relative to critical aspects of "waving" approaches, a few "non-traditional" procedures for LSO training and performance measurement were developed.

1. Application of Signal Detection Theory to Waveoff Decision.

Signal detection (SDT) may be applicable to the waveoff decision as a way to more effectively teach the waveoff and/or to help establish criteria for acceptable waveoff decision performance.

Figure D-2 depicts this concept. The LSO has the choice of whether to accept (no waveoff) or reject (initiate waveoff) an approach. This decision can be thought of as analgous to detecting a signal in a noisy background. The "signal" to be detected, in the LSO's case, is that some aspect of the approach is out of limits, requiring a waveoff. If he detects such a condition, he initiates a waveoff to prevent an accident (such as a ramp strike). Two types of errors are possible. In the worst case, the LSO fails to initiate a waveoff when one is required and the end result is an accident (usually a very costly mistake). In SDT, this is commonly called a Type I error ("miss"). In the other case, a waveoff is initiated when one is not needed. This error results in the necessity for another approach attempt. This is commonly called a Type II error ("false alarm"). This type of waveoff decision error is normally not considered costly.

Due to the potentially tragic and costly consequences of a Type I error, it is very important that the LSO training program be oriented toward developing waving performance which minimizes the occurrence of this error. However, there are a few situations in which a Type II error can be costly. An example is an unnecessary waveoff given to an aircraft on its last approach attempt prior to a controlled ejection or ditching. A Type II error also can lead to an unacceptably low boarding rate. Thus an effective LSO training program must address both types of error, and the relationship between them.

AIRCRAFT APPROACH DYNAMICS

		Waveoff required to prevent accident	Waveoff not required
LSO DECISION	Initiate Waveoff	correct decision	Type II error
	Do not Initiate Waveoff	Type I error (miss)	correct decision

Figure D-2. Waveoff Decision Hypothesis Matrix

According to SDT there are two parameters that influence the probability associated with the decision matrix: d' and B, often called "sensitivity" and "response bias," respectively. The former is associated with the degree to which the two cases (noise only or signal-in-noise) are discriminable by the observer. To a highly experienced and qualified LSO, d' would be relatively large, i.e., his perceptual discrimination between the waveoff and no-waveoff situations usually would be clear. Environmental variables, such as visibility, would decrease d' for any LSO. But the thrust here is that the perceptual learning associated with LSO training increases the d', the ability to discriminate between waveoff and no waveoff situations.

The other measure refers to an internal criterion or decision bias. Shifting the payoffs associated with the Type I and Type II errors would result in shifts in their probabilities of occurrence. In practical terms, this means that even for the skilled LSO with a large d', there will be some approaches that are borderline. Whether he decides to waveoff the approach is determined partly by his decision bias (B). The extremes of the B dimension for an LSO could be described as "I get anybody aboard, no matter what" versus "If they can't show me a rails approach, they can go around".

The important implication for an automated LSO training system is that both d' and B can be calculated, based on the outcome (waveoff/no-waveoff) of a set of approaches. The LSO trainee should be taught: a) that he <u>has</u> a B (decision bias) and; b) that he must learn <u>how far to shift it</u> according to the factors affecting the recovery.

Whether the LSOTS will be able to generate satisfactory measures of d' and B for the waveoff decision is unknown. The concept is straightforward, and the mathematical foundations for SDT are available (Baird and Noma, 1978; Greenstein and Rouse, 1978). The development of automated SDT analysis might best be accomplished by utilizing highly experienced LSOs in the LSOTS (or the LSORD) to establish the data base. These data must be collected anyway in support of the automated measurement of waveoff performance. The SDT application to the LSOTS should be considered as a candidate for inclusion in the Training Development Module.

The SDT concept has several implications for LSO training. The first, as was described above, is to differentiate the relative criticality of two types of waveoff decision errors. Another implication is to use the concept to aid in the logical structuring of influences on the waveoff decision. For example, some typical influences on the LSO which can lead to Type I errors are: boarding pressures from the Air Boss (and others), self-imposed boarding pressures near the end of a CQ period, LSO belief that a usually good pilot will be able to "salvage" a poor approach, and internal pressure brought about by LSO knowledge that an aircraft is low on fuel with no airborne tanker available. Some examples of influences leading to Type II errors include: excessively conservative biasing of the waveoff decision due to recent approach results (in other words "trigger happy"). Thus, the SDT concept could prove useful for effective organization and presentation of waveoff decision instruction, whether or not it is developed as an automated performance measure.

The SDT concept also may be useful in establishing performance evaluation criteria for the waveoff decision task since the two types of errors reflect both the "safe" and the "expeditious" aspects of LSO waving responsibilities. Type I errors are indicative of performance that violates the "safe recovery" responsibility. Type II errors are indicative of performance that is counter to the "expeditious recovery" responsibility.

2. Boarding Rate Effectiveness

A few LSOs have suggested that training must emphasize that the use of "gopher" calls in close is <u>not</u> the proper technique for improving boarding rate under difficult recovery conditions (such as pitching deck, poor weather, aircraft malfunction, etc.). The technique that must be promoted is voice call assistance early in the approach to help get "set up" and minimize deviations as the aircraft nears the waveoff decision point. However, the training program must not promote a general trend of "climbing into the cockpit" by the LSO. The pilot should receive extra assistance only when dictated by recovery conditions.

3. Recovery/Situation Management Concept

A third concept is that of recovery (situation) management. The LSO is a manager of resources during carrier landing (recovery) operations and the training program must promote the job as such. In traditional LSO training this role has not been addressed explicity. The LSO must manage personnel resources on the platform: back-up LSO, hook spotter, phone talker, LSO trainee observers. He must monitor and manage conditions and equipment that affect carrier landing geometery: FLOLS settings (roll angle, basic angle, brightness), ship trim, absence of arresting wires, barricade, MOVLAS, ACLS, and CCA assistance to the pilot. He must coordinate with other organizations in the recovery team (such as Pri-Fly, CATCC, Air Ops) to optimize safety and efficiency of operations.

Proper recognition of the LSO's recovery management role and responsibilities in the training program should help accelerate trainee acquisition of these "big picture" decision skills. The recovery management concept should be an influence on syllabus organization and sequencing; the primary implication being that explicit instruction should be given on some examples of recovery/situation management relatively early in the syllabus. The LSO trainee must learn to alternate his attention between the intense concentration required during control of a single aircraft, and the "big picture" analysis necessary for successful conduct of the entire recovery.

APPENDIX E

TECHNICAL OBJECTIVES AND PROGRESS

TECHNICAL OBJECTIVES AND PROGRESS

The general goal of this project was to develop a model to manage the large amount of instructional information available in an automated training system for LSOs.

The objectives were to identify the functions necessary to:

(1) aid a human instructor by providing a brief on training skill level, maintaining trainee records, and managing automated subsystems;

(2) assess, evaluate, and diagnose LSO trainee peformance during progress through training on an LSOTS;

(3) identify, select, and define tasks appropriate to the skill and profiency level of the individual trainee; and to

(4) develop a model of the LSO instructor that incorporates the above functions;

(5) develop a functional design for a computer software model of the LSO instructor;

(6) develop a preliminary syllabus derived from the LSO knowledge base.

We believe that all of the technical objectives have been met. Information satisfying objectives 1 through 4 is contained in Appendix A. The functional software design (objective 5) is presented in Appendix B. The LSO knowledge base and preliminary syllabus (objective 6) are given in Appendix C. Additional information, data, and rationale for the instructor model are given in Appendix D.

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